THE ROCKEFELLER FOUNDATION

Program in the

Agricultural Sciences

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THE ROCKEFELLER FOUNDATION

Program in the

Agricultural Sciences

ANNUAL REPORT
1959–1960

THE ROCKEFELLER FOUNDATION 1913
THE WELLBEING OF MANKIND THROUGHOUT THE WORLD

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FOREWORD

Improved nutrition and health are basic aspirations of mankind. The production of ample supplies of food is an especially challenging problem to those less technologically advanced countries participating in the surge to achieve economic and social improvement.

The Rockefeller Foundation program in the Agricultural Sciences, initiated in 1943, is designed to increase food production through cooperative efforts in research and education. The program rests upon the realization that advances in agricultural technology must be fitted to the problems and potentials of diverse agricultural scenes. Research to improve the output and quality of selected food crops and training designed to strengthen local scientific technical leadership have produced measurable benefits in those countries in which cooperative programs have been conducted.

This report of the Foundation's Agricultural Sciences program is presented to record the scope of these activities and the progress that has been made toward the goals established in the various cooperative endeavors.

DEAN RUSK

THE ROCKEFELLER FOUNDATION

Program in the

Agricultural Sciences

Director's Introduction

The Rockefeller Foundation program in the agricultural sciences is designed to help the people of the world, and especially those in the technologically less advanced sections of it, improve their nutrition by growing more food. To bring annual rates of increase in agricultural production to figures higher than the rates of population increase is generally recognized as perhaps the second most compelling challenge mankind faces in the next few decades.

The problem of feeding an "exploding population" was foreseen by some leaders in public affairs and public health several decades ago. Among those who realized it especially well were officials of The Rockefeller Foundation who had long been intimately acquainted with public health and population trends in this country and abroad. They realized that the primitive agricultural systems characteristic of many countries could not possibly support the increased populations which would result from lower mortality rates in association with continued high birth rates.

In 1941 the Foundation explored the agricultural problems in a neighboring country, Mexico, where the population was already expanding rapidly, and where the Foundation had worked in public health since 1919. In 1943 the Mexican government and the Foundation inaugurated a cooperative effort in agricultural improvement which was initially implemented by a one-man mission. From this has grown the present agricultural program of the Foundation, of which this volume is the first comprehensive published report.

Mexico during the last ten years has enjoyed an average annual increase in agricultural production of 7%, a period when the population was growing at an annual rate of about 3%. The report of the Food and Agriculture Organization of the United Nations, from which these figures are taken, also indicates that the rate of increase in agricultural production in Mexico is among the highest in the world. Naturally no one program or organization can assume sole credit for this achievement, but the improved plant materials and production practices, and the qualified agronomists developed through cooperative research and training have played a significant role in making the advance possible.

The plan of cooperation developed in Mexico has since been extended to three other countries, and from it have evolved hemisphere-wide cooperative projects for the improvement of corn and wheat and a world-wide program of rice improvement. Though relatively small both in staff and financing, this plan, designed to study and solve agricultural production problems where they exist, has furnished a solid base for development of agricultural technology oriented to the requirements of the host country.

The Foundation's program consists of three interrelated centers of emphasis. The phrase "centers of emphasis" is used deliberately to stress the fact that the three principal activities are interrelated and each contributes to the objective of the whole program.

The operating units are the first center of emphasis. In these, Foundation staff members reside in the country concerned to lead research projects for the improvement of locally important food crops and methods for their production, and to train young scientists in the philosophy and methods of agricultural experimentation. Through cooperative financing they are provided with the necessary facilities such as experiment stations, laboratories, libraries, and transportation. These staff members enter technical assistance on a career basis and become proficient in the local language.

The second center of emphasis is a scholarship and fellowship program flexible enough to start where the local educational systems leave off and with a ceiling high enough to carry through to the doctoral and postdoctoral levels. Though most intensively employed in those countries where operating units are located, the award of scholarships and fellowships is by no means limited to them.

The third center of emphasis is the provision of funds to selected institutions in support of research and training. In countries where agricultural technology is less advanced, these grants are characteristically directed toward strengthening local institutions. In more advanced countries, the grants are chiefly made to support research in fundamental principles, in the hope that the results may eventually be of international value in agricultural improvement.

In the sections which follow, these three centers of emphasis will be described more at length.

THE OPERATING UNITS

In Mexico, through a course of cooperative experimentation and evaluation, the pattern of procedures was worked out which underlies the agricultural improvement projects in this and the other countries where operating units are located.

The concept of a jointly supported and jointly staffed research and training unit emerged early from the discussions between representatives of the Government of Mexico and The Rockefeller Foundation. The Office of Special Studies, created within the Ministry of Agriculture to implement the plan, began operation in Mexico in 1943.

By invitation from the Government of Colombia, an Office of Special Investigations was set up in the Ministry of Agriculture of that country in 1950. A similar invitation extended by the Government of Chile led to the establishment of an Office of Special Studies in the Chilean Ministry of Agriculture in 1955. The Indian Agricultural Program, begun in 1956, does not have a "special office" title but it operates in general in the same way as the Latin American programs, in cooperation with the Ministry of Food and Agriculture, the Indian Council for Agricultural Research, and the several state governments.

The staffs of the Latin American offices consist of scientists assigned from its own personnel by The Rockefeller Foundation, scientists of the country concerned at both junior and senior grades assigned by the ministries, and visiting scientific aides provided usually by the Foundation. In India the Foundation staff members have positions in the Post Graduate School of the Indian Agricultural Research Institute and in the crop improvement schemes of the Indian Council for Agricultural Research. Resident Foundation staff members in Mexico number 16, in Colombia 16, in Chile 4, and in India 10.

Both the Foundation and the governments contribute to the budgets of the Latin American offices and to the Indian program. For 1959 the Foundation appropriated $233,970 for its share in Mexico; $203,150 in Colombia; $156,100 in Chile; and $209,960 in India. For 1960 the figures were: Mexico, $275,850; Colombia, $192,350; Chile, $173,750; and India, $255,585. These amounts are exclusive of Foundation staff salaries. In each instance the contribution of the Foundation is less than half the total budgets of the offices and of the Indian programs, and the proportion of the Foundation's share to the totals has been decreasing steadily as the governments assume more and more of the financial responsibility.

Each of the offices operates a number of experiment stations and directs the scientific work in a number of others. In Mexico the Office of Special Studies has headquarters in Mexico City, central laboratories and an experiment station at Chapingo in the Valley of Mexico, and regional stations for the tropics, for the high altitudes, for the intermediate altitudes, and for irrigated agriculture in the dry northwest, and a range management station in the northern plains. In Colombia the Office of Special Investigations has headquarters in Bogotá and conducts research on and helps administer all the federal experiment stations, 13 in number. In Chile the Office of Special Studies in Santiago directs and administers two experiment stations of the federal government and cooperates with the work of the stations connected with the country's four universities. In India the program staff members direct the technical aspects of the scheme for the improvement of maize at 16 stations and for the improvement of sorghum and millets at 10 locations.

In all the countries the research and training are directed toward increased production of the food crops basic to the local diets. Export and plantation crops have been dealt with only incidentally. The work in Mexico began with investigations leading to the improvement of corn, wheat, and beans. Supporting studies in soil science, entomology, and plant pathology were soon added and a library started. Through the years new sections were created for work with additional crops, until now most of the important cereals, vegetables, potatoes, and forages are under systematic investigation. Sections on agricultural economics and agricultural information were inaugurated more recently.

In Colombia the original programs dealt with corn and wheat; soil science and plant protection represented the first expansion of the cooperative effort, and intensive study of the potato, more important for food than the cereals in the high altitudes, was soon begun. Today the research sections in the Office of Special Investigations cover all the important grains, including rice.

Wheat improvement was the initial project established in the Chilean program; the forage grasses and legumes came next. In India two crops are being investigated—maize, and the sorghums and millets. Corn is still planted on a limited acreage in India today but has not been fully exploited as a food and feed crop. Sorghum and the millets represent the main food of some 35% of the Indian population.

As will be evident from the foregoing account, all four programs began with chief emphasis on foods derived from plants. Corn in various forms is still the chief reliance of some 60% to 65% of the population of Latin America, supplemented by wheat bread in urban areas and by potatoes where they can be grown. For the improvement of the quality of the diet in these countries, however, the production of animal proteins must be greatly increased. When grain harvests are insufficient even to meet the demands for human food, an adequate small-animal industry is impossible, and range cattle production remains at a primitive level. As grain production is increased in countries like Mexico and Colombia, more grain can be used for feeding animals, especially the small animals such as poultry. Reflecting this trend, the Latin American programs began to move into the field of animal production, first establishing sections dealing with the forage grasses and legumes and with range management. These have now been supplemented by sections dealing directly with animals: poultry production, including both management and disease control in Mexico, and poultry and dairy and beef animals in Colombia. It is probable that increasing proportions of these programs will in the future be devoted to the improvement of diets through encouraging the production of animal proteins.

In all of the cooperative projects, emphasis is placed on bringing about improvements in both plant and animal production in the minimum of time. The collection and evaluation of locally grown varieties and the study of introduced varieties frequently result in the isolation of varieties superior to those commonly grown. In Mexico, superior corn, wheat, and bean varieties were soon selected from local and introduced materials and released for use by farmers, and several introduced alfalfa and grass varieties proved adequate for prompt recommendation. The corn collections initiated in Mexico and Colombia focused attention on the need for building up germ plasm banks for this important crop of the Americas, as a basis for more advanced breeding and as a resource for the improvement of corn in other countries.

Breeding programs for the production of higher-yielding varieties with better disease and pest resistance began concurrently with the collection phase but naturally took longer to reach the stage of commercial release. Both in Mexico and Colombia two plant generations can be grown in a single year, in convenient locations, because of the sharp climatic differences due to different altitudes. This has helped to reduce the time required to develop new hybrid and synthetic corn varieties and improved varieties of wheat and other crops.

Interdisciplinary cooperation has been stressed from the first in all the programs. In primitive agriculture, poor soils, plant diseases, insect pests, weed competition, wasteful cultural practices, and losses in transportation and storage, no less than inferior seed, limit the net food productivity level. Similar handicaps limit poultry and animal production. The breeding and selection of superior varieties has always gone hand in hand with investigations of soil problems, disease and pest control, and management or cultural practices, so that the information accumulated combines attention to a major portion of the factors necessary for maximum yield and quality.

The operating units are concerned primarily with research and principal emphasis is placed on applied studies directed toward the improvement of the quantity and quality of the chief food crops. A certain amount of demonstration and farmer education has inevitably been associated with the investigative efforts. In regional adaptation trials, for instance, thousands of plots have been planted on the land of private farmers. At all the experiment stations demonstration plots are regularly grown for the benefit of visitors, and all the stations feature one or more annual open-house field days when farmers and the general public are invited to see the work in progress. These field days have been increasingly popular and attendance figures of up to 3,000 are now commonplace.

Extension work, as such, has not been included within the scope of the operating programs. The Foundation does not have the requisite manpower and also, the task of persuading farmers to adopt improved practices is usually best done by their fellow nationals. To aid the extension activities in Mexico the Office of Special Studies has had for several years an agricultural information service to assist in demonstrating how research results can be translated into terms which extension agents can easily convey to farmers. The information is adapted to all the chief media—bulletins, circulars, and newspaper, radio, and television features. Recently a highly successful series of 16 mm movies, in color and with sound, was launched. The Foundation has also given technical direction and financial support to a pilot extension experiment in the State of México.

Similarly the work of increasing the seed of new varieties to commercial quantities is the province of agencies established by the governments for this purpose. In Mexico the increase and distribution of corn seed is the responsibility of the National Maize Commission and that of other crops is handled within the Ministry of Agriculture. In Colombia seed increase and distribution is handled by the Caja de Crédito Agrario, Industrial y Minero, the national agricultural credit bank, with branches in all the important agricultural regions. In Chile and India improved seed distribution systems are being planned.

NEW DEVELOPMENTS

Just as the new operating units evolved from the pattern of the first one, so from the operating units as a whole have evolved three international programs which are still in their initial phases.

The first, an inter-American maize improvement program, is visualized as contributing to all the countries of the Western Hemisphere and even in its first year has operations in a number of them. The improved varieties and promising lines of corn developed in Mexico and Colombia are being made more conveniently and systematically available to cooperating plant breeders in all Latin American countries. The corn germ plasm banks in Mexico and Colombia are being completed and the collections classified into types suitable for further evaluation and use in breeding projects. The training of scientists who will specialize in corn improvement is being facilitated.

The second, a wheat improvement program, will similarly cover both continents in the Western Hemisphere and in addition lend assistance to wheat improvement in the Near and Middle East. In operation only a few months, this program has already arranged a uniform yield nursery which is being planted in 15 different countries.

The third, the International Rice Research Institute, represents an idea evolved from but not organizationally connected with the Foundation's other operating units and programs. Located at Los Baños in the Philippines, the Institute is governed by its own Board of Trustees whose members represent several of the important rice-producing countries of Southeast Asia. The Ford

Foundation appropriated $7,100,000 for preliminary expenses and for the construction of the buildings of the Institute. The Government of the Philippines arranged for favorable legal status for the Institute and its staff. The College of Agriculture of the University of the Philippines provided land for an experimental farm, and will cooperate closely with the Institute. The Rockefeller Foundation is undertaking the administration and scientific direction of the Institute and has already assigned two staff members from its own personnel. The Foundation also appropriated $185,000 for initial costs and for the first year's budget.

The central purpose of the Institute is to conduct both basic and applied research on the rice plant and the improvement of its yield and quality. A scientific staff of 15 to 20 senior scientists is planned. Each of these will also direct the training of younger scientists who will be brought to Los Baños on Foundation and other scholarships. The Institute will collect and maintain a library of the world's literature on rice, will sponsor seminars and conferences, and will disseminate research results.

The plans for the grounds and buildings were completed in the spring of 1960 and construction was started later during the year. Completion of the buildings is expected in 1961, and by 1962 the Institute should be in full operation. Reports of its progress will be issued separately and are not included in this volume.

FELLOWSHIPS AND SCHOLARSHIPS

The award of fellowships and scholarships for advanced training, in Rockefeller Foundation practice, is not an end in itself but a means to be used along with others for achieving the purposes of a specific program. In the agricultural sciences such training awards, like grants and operating units, are employed to strengthen agricultural research and education and to build up agriculture as a profession, especially in the less well developed countries.

The Foundation began awarding fellowships in 1917 and through the years has evolved a set of rather simple operating guidelines. The awards are made only to people who have completed their training through the college level, and who are at work in a university or agency which will grant them leave of absence for study and also assure them a future post in which they can make effective use of their training experience.

In more advanced countries the application of these guidelines offers no special difficulties. Professional school graduates can be presumed qualified and in most places good positions await the trainee upon his return.

In countries less advanced agriculturally, in contrast, a troublesome gap usually separates the qualifications for graduation from local professional schools, from those required for admission to graduate schools in advanced countries. In most underdeveloped countries, similarly, agriculture as a profession is at such a low level that a trainee's increased competence is not always appreciated and utilized and so may be of little help to him upon his return.

In this situation the operating units have proved a most useful bridging mechanism. The trainees, working with Foundation staff, are introduced to the experimental methods and study skills needed in graduate work and are guided in making up academic deficiencies. Furthermore, the operating unit itself is the agency which grants leaves of absence for study and which assures the trainees positions with increased responsibility when they return from training.

In the operating units the training experience of a good many young men and women begins in their undergraduate years. The central experiment station in Mexico, at Chapingo, adjoins the campus of the National School of Agriculture; students can earn pocket money by working at the station in the afternoons and on holidays. All the offices encourage applications for paid vacation jobs from students in the local agricultural colleges. Though their work is at a simple level, the young people see modern experimental methods in operation and get an idea of what professional agriculture is like. The members of the staffs who supervise their work also have the opportunity to evaluate the ability and interest of the undergraduates.

The junior staff, or trainees, of the offices are recruited from these part-time workers and from other college of agriculture graduates. One attraction of the training positions in Latin American countries is the aid which the senior staff give the trainees with their thesis research. Upon completion of his course work the graduate of a Latin American college of agriculture becomes a "pasante." The baccalaureate degree, "Ingeniero Agrónomo," is conferred only after the completion of a thesis and its successful defense in oral and written examinations. Since civil service rating as a professional agronomist depends upon having the degree, guidance in thesis preparation is a valued aid.

From the trainees, the Foundation staff members select the best each year for scholarship awards for study toward the master's degree. In the past, candidates had to have a sufficiently good command of English to profit from study in the United States. Now that the Graduate School of the National School of Agriculture in Mexico is in successful operation, mastery of English is no longer a *sine qua non* and a number of office trainees have elected to use their scholarships there. Nationals of other Latin American countries are also accepted at Chapingo.

In the typical course of training, a young man or woman who has taken the master's degree normally returns to his home country for further experience at a more responsible level either with the office or with an associated agency. From this group a few are selected each year for scholarship or fellowship awards for study toward the doctoral degree. In the future the Graduate School at Chapingo may offer work at the doctoral level but for the present those who have advanced this far will continue to go to universities in the United States.

As Latin American agricultural colleges put more emphasis on laboratory and field experimentation in undergraduate courses, the amount of training experience needed by their graduates as preparation for graduate study concomitantly decreases. The number of years between the pasante and the M.S. or Ph.D. is being reduced. Some young people now in the United States are working straight through to the doctorate without interruption after the master's degree.

When the trainees go for advanced training they are given study leave and assurance of a position to which to return. Previously this assurance was an important consideration for the young men and women embarking on advanced study but more recently agricultural development in many Latin American countries has advanced so fast that the demand for trained people outruns the supply. Former members of the offices are to be found in responsible positions in government agencies, on the faculties of agricultural colleges, with producers' and farmers' associations, and with agricultural chemical and equipment companies.

In the Mexican and Colombian operating units, senior staff positions are beginning to be filled by highly competent nationals, many of whom have been trained with Foundation aid. In Mexico the directors of all the experiment stations of the Office of Special Studies are former scholars and fellows, as are most of the chiefs of the research sections at the stations. In the office itself the chiefs of four sections are former trainees. In Colombia the director of the research division of the Ministry of Agriculture is a former Foundation fellow and the Office of Special Investigations has assigned the direction of a major research section to another.

The Foundation's operating units are thus "self-liquidating" in the sense that as the training program produces qualified scientists, the work will be turned over to them and the Foundation's staff will be freed for other assignments.

Beginning on page 275 is a list of the fellows and scholars in the agricultural sciences who studied in the United States or elsewhere during the period from January, 1959, to June, 1960. Of the 342 listed, 87 were sponsored by Foundation operating units and 255 by other institutions or agencies.

The total number of fellowships awarded in the agricultural sciences is 426, from some 50 countries, including some awards in the 1920's and 1930's which predate the establishment of a formal program in 1943. In the scholarship plan, begun in 1947, a total of 356 awards has been made to young people from 25 countries.

AID TO RESEARCH AND TEACHING

The third center of emphasis in The Rockefeller Foundation's program in the agricultural sciences is the granting of funds to support research and teaching. The grants vary along a wide spectrum, ranging from help to agencies closely connected with the Foundation's operating units, through efforts to strengthen agricultural education in countries where the institutions are not yet able to train enough technicians and scientists, to the support of research at the frontiers of knowledge. The reader will find the grants made from January, 1959, through June, 1960, in a list beginning on page 265.

Illustrative of the grants for research are those for the continuance of studies on the biochemical aspects of obligate parasitism, on the nature of gene action in quantitative inheritance, on senescence in plants, on the genetic potentialities of wheat and of the pathogens which prey upon it, and on the use of solar energy in underdeveloped countries.

In aid of agencies closely associated with the Foundation's operating units can be cited an allocation of $400,000 for improvement and equipping of experiment stations in Chile, and one of $75,000 to expand the publication and visual aids section of the extension service of the Ministry of Agriculture in Mexico (these are not listed among the grants because they are disbursed through Foundation offices). In this group also are substantial grants to other institutions with which operating units work closely: the Faculty of Agronomy of Catholic University of Chile, the Graduate School of the National School of Agriculture in Mexico, and the School of Veterinary Medicine of the National University of Colombia.

Allied to the Foundation's own training plans are the scholarships administered by other agencies for which the Foundation provides funds. An appropriation of $100,000 to the College of Agriculture of the University of Hawaii will help students from Asian and Pacific Basin countries attend that institution and another grant of the same amount will bring students from Southeast Asian countries to Los Baños for study at the College of Agriculture of the University of the Philippines. The rice research centers at Louisiana State University and at Texas Agricultural and Mechanical College annually receive numerous foreign students and visitors; the Foundation has made grants to enable both institutions to enrich the experience and value which the visitors will gain from the contact.

By far the largest number of grants are those in countries challenged to improve their agricultural research and education. Considerable emphasis is placed on the "travel grants" which enable administrators and faculty members of foreign colleges and research centers to visit similar institutions in other countries, particularly the United States. In a few instances grants are made to help professors in the United States acquaint themselves with educational conditions abroad. The Foundation has traditionally used this type of grant freely to establish mutually profitable international contacts, and to widen intellectual horizons.

Several larger grants are directed toward the strengthening of departments and colleges in foreign countries. Among these are $26,300 to the Institute of Agriculture of Lovanium University in the Congo; $65,000 to the West Bengal State College of Agriculture, India; $135,000 to Coimbatore Agricultural College and Research Institute, India; and $171,000 to the Siriba Training College for African Students, Kenya.

Two rather special sets of grants merit comment.

When in 1957 Poland began to open her windows which look toward the West, the Foundation was pleased to be invited to renew an association with that country which dates back to the time of World War I. Officers of the Foundation representing the medical, natural, and agricultural sciences visited Poland and reported that the restoration of communication between the Polish and the Western scientific communities represented a most desirable and mutually appealing endeavor. Accordingly the Foundation made a large number of small grants to help libraries update their collections of Western journals and books, to enable laboratories to purchase modern equipment, and to make it possible for Polish scientists to reestablish personal contact with their Western colleagues. The initial special phase of this effort is now ended and it has been consolidated with the Foundation's regular program.

The second set is the group of grants made in Africa. These represent the early stage of a systematic effort by the Foundation to acquaint itself with the potentials for improvement of agricultural technology in this important part of the world. As will be observed, for the most part the grants are small and exploratory but they number 28 individual actions and total $456,420. Already contacts have been established in the Congo, Ethiopia, Kenya, Nigeria, Rhodesia and Nyasaland, the Sudan, Tanganyika, and Uganda.

The sections which follow are the individual reports of the operating units, arranged in the order of their founding: Mexico, Colombia, Chile, India, and the Inter-American Food Crop Improvement Program. At the end of the book is a consolidated list of staff publications issued during the period covered by this report, as well as the lists of grants and of scholarships and fellowships already referred to.

Financial Summary

Program in the Agricultural Sciences
1941 through 1959

OPERATING PROGRAMS

Mexico	$6,646,504.90	
Colombia	3,178,551.37	
India	1,756,857.45	
Chile	1,504,248.67	
Central American Corn Improvement Program	285,252.78	
Philippines	235,494.38	
Inter-American Food Crop Improvement Program	100,000.00	
General	154,925.48	$13,861,835.03

FELLOWSHIPS AND SCHOLARSHIPS

Fellowships		
Regular Program	$2,536,994.36	
Expanded Program	1,950,727.43	
Polish Science Program	205,641.00	
Latin America—Scholarships	1,036,126.48	
Mexico—Scholarships	196,112.65	5,925,601.92

GRANTS PROGRAM

United States	$5,694,921.83	
South America	4,261,201.07	
The Far East	3,547,732.39	
Mexico	1,219,146.12	
Europe	684,420.56	
Central America	452,092.51	
Africa	354,383.54	
Near East	232,950.56	
Canada	10,622.14	
General	31,011.70	16,488,482.42
Total grants, 1941 through 1959		$36,275,919.37

Mexican Agricultural Program

Personnel

MEXICAN AGRICULTURAL PROGRAM

MINISTRY OF AGRICULTURE

His Excellency, **Don Julian Rodríguez Adame,** ING. AGR., Minister of Agriculture
Jesús Patiño Navarrete, ING. AGR., Subsecretary of Agriculture
Daniel Mercado García, D.V.M., Subsecretary of Livestock
Esteban Uranga Prado, ING. AGR., Executive Officer
Joaquín Loredo Goytortua, ING. AGR., Director General of Agriculture

OFFICE OF SPECIAL STUDIES
(OFICINA DE ESTUDIOS ESPECIALES—"OEE")

Ralph W. Richardson, Jr., PH.D., Local Director OEE, The Rockefeller Foundation
Douglas Barnes, PH.D., Assistant Field Director OEE, The Rockefeller Foundation
John A. Pino, PH.D., Assistant Field Director OEE, The Rockefeller Foundation
Nicolás Sánchez Durón, PH.D., Assistant Technical Director OEE

DIRECTORS OF INVESTIGATION AND OPERATION MANAGERS

Ramón Gómez Jasso, ING. AGR., Manager, El Horno Experiment Station, Chapingo, México
Rogelio Villarreal Guzmán, ING. AGR., Manager, La Cal Grande Experiment Station, Guanajuato
Jorge Martínez Lima, ING. AGR., Manager, El Cayal Experiment Station, Campeche, Campeche
Javier Gil Flores, ING. AGR., Temporary Manager, El Roque Experiment Station, Celaya, Guanajuato
Carlos Tapia Jasso, M.S., Director, Cotaxtla Experiment Station, Veracruz
Raymundo Gudiño Morales, ING. AGR., Manager, Cotaxtla Experiment Station, Veracruz
Samuel Aguilar Yépez, ING. AGR., Temporary Manager, CIANO Experiment Station, Ciudad Obregón, Sonora

VARIETAL IMPROVEMENT IN CORN AND SORGHUMS

Robert D. Osler, PH.D., Geneticist, The Rockefeller Foundation
Elmer C. Johnson, PH.D., Geneticist, The Rockefeller Foundation
Gilberto Palacios de la Rosa, PASANTE, Assistant in charge, Corn Breeding, El Horno, Chapingo
Antonio Garza Montemayor, M.S., in charge, Corn Improvement, Bajío
Fidel Márquez Sánchez, PASANTE, in charge, Corn Improvement, Cotaxtla
Oscar Cota Agramont, PASANTE, in charge, Corn Improvement, CIANO, Ciudad Obregón
Juan Manuel Muñoz Garza, M.S., in charge, Sorghum Improvement, Bajío
Facundo Barrientos Pérez, ING. AGR., Assistant in Corn Improvement, Central Mesa (returned to OEE February, 1960)
Hermilo Hugo Angeles Arrieta, M.S., Assistant in Corn Improvement (returned to OEE February, 1960)
Francisco Obregón Hernandez, PASANTE, Research Aide in Corn Improvement, State of México Program
Adrián Aguado Turrubiate, PASANTE, Research Aide in Corn Improvement, El Horno, Chapingo
José Torres Martínez, PASANTE, Research Aide in Sorghum Improvement, Bajío
Joaquín Ortiz Cereceres, PASANTE, Research Aide in Corn Improvement, Cotaxtla
Jesús Neve Vargas, ING. AGR. (on leave)
Marco Antonio Wing Martínez, ING. AGR. (on leave)

VARIETAL IMPROVEMENT IN SMALL GRAIN CROPS

Ignacio Narvaez Morales, PH.D., Wheat Breeder, OEE Staff
Alfredo García Sánchez, ING. AGR., Assistant Wheat Breeder, CIANO, Ciudad Obregón
Gregorio Vázquez Guillén, M.S., Assistant Wheat and Barley Breeder, La Cal Grande
Silvestre Espino Tejeda, M.S., Assistant Wheat and Barley Breeder (returned to OEE May, 1960)
Neftalí Calixto Cruz, ING. AGR., Assistant in charge, Rice Improvement, Cotaxtla
Arnoldo Amaya Celis, PASANTE, Research Aide in Barley, El Horno, Chapingo
Mario Vela Cárdenas, PASANTE, Research Aide in Wheat, El Horno, Chapingo
Vicente Zacarías Dávila, PASANTE, Research Aide in Barley, Bajío
Federico Castilla Chacón, ING. AGR., in charge, Milling and Baking Laboratory, Chapingo
Evangelina Villegas, Biologist and Chemist, Milling and Baking Laboratory, Chapingo
Alfredo Campos Tierrafría, PH.D., Professor of Plant Pathology, Graduate Faculty, National School of Agriculture, Chapingo; Cooperator, Wheat Program, OEE
Eduardo R. Garza Falcón, ING. AGR. (on leave)
Manuel García Alvarez, ING. AGR. (on leave)
Manuel Navarro Franco, ING. AGR. (on leave)
Aristeo Acosta Carreón, M.S. (on leave)
Jacobo Ortega Castro, M.S. (on leave)
Clemente Vázquez Guillén, ING. AGR., Research Aide, El Horno, Chapingo, Inter-American Food Crop Improvement Program (Wheat)

VARIETAL IMPROVEMENT IN BEANS AND SOYBEANS

William D. Yerkes, Jr., PH.D., Plant Pathologist, The Rockefeller Foundation
Graciano Patiño Méndez, M.S., in charge, Bean and Soybean Improvement, El Horno, Chapingo
José Luis Serrano Palencia, ING. AGR., in charge, Soybean Improvement, Cotaxtla
Celio Barriga Solorio, M.S., in charge, Bean and Soybean Improvement, CIANO, Ciudad Obregón
Armando Rubio del Cueto, ING. AGR., Assistant in charge, Bean and Soybean Improvement, El Horno, Chapingo
Salvador Miranda Colín, ING. AGR., Research Aide, El Horno, Chapingo
Francisco Cárdenas Ramos, M.S. (on leave)
Eugenio Martínez Salazar, M.S. (on leave)
Eduardo Casas Diaz, ING. AGR. (on leave)
Alfonso Crispín Medina, M.S. (on leave)

HORTICULTURE

Ernest H. Cásseres, PH.D., Horticulturist (on loan from Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica)
Eduardo Alvaréz y Luna, PH.D., Horticulturist (returned to OEE May, 1960)
Enrique Guzmán Martínez, ING. AGR., Assistant in charge, Horticulture, Santa Elena Experiment Station, Toluca, México
Martín Garatuza Rodríguez, ING. AGR., Vegetable Seed Production Specialist, Cooperative Program between OEE and General Directorate of Agriculture, Culiacán, Sinaloa
Enrique Andrade Arias, PASANTE, Research Aide, El Horno, Chapingo
Víctor Nieto Hatem, ING. AGR., Assistant in charge, Horticulture, CIANO, Ciudad Obregón
Juventino Contreras Guillén, PASANTE, Assistant in charge, Horticulture, Cotaxtla
Josué Kohashi Shibata, M.S., Assistant Horticulturist, El Horno, Chapingo
Ignacio Muñoz Flores, PASANTE, Research Aide, CIANO, Ciudad Obregón
Guillermo Hernández Bravo, ING. AGR. (on leave)

IMPROVEMENT OF FORAGE GRASSES AND LEGUMES

Roderic E. Buller, PH.D., Agronomist, The Rockefeller Foundation
Martín H. González, M.S., in charge, Range Program, La Campana Experimental Ranch, Chihuahua
Arturo Sánchez Durón, M.S., in charge, Forage Program, El Horno, Chapingo
Candelario Carrera Márquez, M.S., in charge, Forage Program, La Campana
Fiacro Martínez Martínez, PASANTE, Assistant in Range Program, La Campana
Marcial Velasco, ING. AGR., Research Aide in Range Program, La Campana
Mario Ferrer Fernández, ING. AGR. (returned to OEE February, 1960)
Ricardo Garza Treviño, ING. AGR. (returned to OEE April, 1960)
Angel Ramos Sánchez, PASANTE, Research Aide in Forage Program, Cotaxtla
Carlos López de la Garza, ING. AGR., Assistant in Range Program, La Campana
René Valdivieso Gutiérrez, ING. AGR. (on leave)
Pedro Sánchez de la Cruz, ING. AGR. (on leave)

SOIL PRODUCTIVITY AND MANAGEMENT

Reggie J. Laird, PH.D., Soil Scientist, The Rockefeller Foundation
Enrique Ortega Torres, PH.D., in charge, Soil Laboratory and Soil Research, CIANO, Ciudad Obregón (until August, 1959)
Zeferino Arvizu Rosales, ING. AGR., in charge, Soil Program, Bajío
Justo Ruiz Meraz, PASANTE, in charge, Soil Program, Cotaxtla
Felix Ramírez Paz, ING. AGR., Research Aide, El Horno, Chapingo
Sabino Chávez Ruiz, ING. AGR. (returned to OEE June, 1960)
Fidencio Puente Flores, ING. AGR. (returned to OEE June, 1960)
Fernando Coronel Torres, ING. AGR., Research Aide, Cotaxtla
Gildardo Carmona Ruiz, PASANTE, Research Aide
Antonio Turrent Fernández, ING. AGR., Research Aide, El Horno, Chapingo
Arnulfo Rosales y González, PASANTE, Research Aide, El Horno, Chapingo
Ignacio Navarro González, PASANTE, Research Aide, Bajío
Roberto Núñez Escobar, ING. AGR. (on leave)

INSECT PESTS AND THEIR CONTROL

William R. Young, PH.D., Associate Entomologist, The Rockefeller Foundation
Alejandro Ortega Corona, PH.D., Assistant Entomologist, OEE Staff
Rodolfo Quintana Rodríguez, M.S., in charge, Entomology Program, El Horno, Chapingo
Juan Antonio Sifuentes Aguilar, M.S., in charge, Entomology Program, CIANO, Ciudad Obregón
José Luis Carrillo Sánchez, ING. AGR., Curator of Insect Collection
Hermenegildo Velasco Pascual, PASANTE, Research Aide, Cotaxtla
Juan Villanueva Barradas, PASANTE, Research Aide, Cotaxtla
Joel Rodríguez Vélez, PASANTE, Research Aide, CIANO, Ciudad Obregón
Ernesto de las Casas Aguirre (on leave)
Rafael Padilla Aranda (on leave)
Francisco Pacheco Mendívil, M.S. (on leave)

PLANT DISEASES AND THEIR CONTROL

John S. Niederhauser, PH.D., Plant Pathologist, The Rockefeller Foundation
Jorge Galindo, M.S., in charge, Plant Pathology Laboratory, El Horno, Chapingo
Homero Gaona Rodríguez, M.S., Research Aide, in charge, Plant Pathology Program, Cotaxtla
Santiago Fuentes Fuentes, M.S., in charge, Field Crop Disease Studies, El Horno, Chapingo
Antonio Eliseo Rodríguez Valdez, PH.D., in charge, Corn Disease Studies, El Horno, Chapingo
Gelasio Pérez Ugalde, ING. AGR., Research Aide, El Horno, Chapingo
Luis César López Frías, PASANTE, Research Aide, El Horno, Chapingo
Armando Campos Vela, ING. AGR., Research Aide in Potato Improvement, El Horno, Chapingo
Jesús Castro Franco, PASANTE, Research Aide, El Horno, Chapingo
Daniel Téliz Ortiz, PASANTE, Research Aide, El Horno, Chapingo
Santiago Delgado Sánchez, ING. AGR. (on leave)
Sebastian Romero Cova, ING. AGR. (on leave)
Edmundo Dávila Guzmán, ING. AGR. (on leave)
Javier Cervantes Romo, ING. AGR. (on leave)

WEEDS AND THEIR CONTROL

Jorge Nieto Hatem, M.S., in charge, Weed Control Research, Cotaxtla
Omar Agundis Mata, M.S. (returned to OEE May, 1960)

ANIMAL SCIENCES

John A. Pino, PH.D., Animal Scientist (Poultry), The Rockefeller Foundation
Arturo Rojas Stiller, PASANTE, Research Aide
Luciano Crispín Medina, ING. AGR., Extension Specialist (Poultry), Santa Elena, Toluca
Edsel J. Bixler, PASANTE, Research Aide
Guillermo Ojeda Chablet, CHEMIST, Research Aide
Gustavo Reta Peterson, M.D., VETERINARIAN, Research Aide
Augusto Aguilera Amezcua, M.S. (on leave)
Manuel Cuca García, ING. AGR. (on leave)

VETERINARY MEDICINE

Daniel D. Hagen, D.V.M., Associate Animal Pathologist, The Rockefeller Foundation
Eduardo Rivera Cruz, M.D., VETERINARIAN, in charge, Diagnostic Laboratory, National University of Mexico
Jesús Estudillo, M.D., VETERINARIAN, in charge, Poultry Research, National University of Mexico
María del Carmen Vásquez de Crispín, BIOCHEMIST, BACTERIOLOGIST, Research Aide, Santa Elena, Toluca
Julio César Ramírez Aceituno, M.D., VETERINARIAN, in charge, Poultry Disease Diagnostic Laboratory, Santa Elena, Toluca
Salvador Váldez Alvarez, ING. AGR., Research Aide (Swine)
Ana María Lara Franco, BIOCHEMIST, BACTERIOLOGIST, Research Aide, National University of Mexico
Ricardo Moreno Chan, M.D., VETERINARIAN (on leave)

AGRICULTURAL ECONOMICS

Donald K. Freebairn, PH.D., Associate Agricultural Economist, The Rockefeller Foundation
José Soto Angli, PASANTE, Research Aide
Francisco Jacinto Andrade, PASANTE, Research Aide
José S. Silos Alvarado, ING. AGR. (on leave)

LIBRARY

Pablo Velásquez J., M.S., in charge, Library, OEE staff

SEED LABORATORY

Juan José Barreiro Sánchez, PASANTE, Research Aide
Daniel Guerrero Sandoval, M.S. (on leave)

AGRICULTURAL INFORMATION

Delbert T. Myren, PH.D., Associate Information Specialist, The Rockefeller Foundation
Neil B. MacLellan, Staff Photographer, The Rockefeller Foundation
Mario Gutiérrez Jiménez, Assistant Information Specialist, OEE Staff
Leobardo Jiménez Sánchez, PASANTE, in charge, Information Department, Cotaxtla
Abdo Magdub Méndez, PASANTE, Assistant Information Specialist, Cotaxtla
Gregorio Martínez Valdés, PASANTE, Research Aide in Publications
Juan Antonio Canizales D., PASANTE, Research Aide in Publications
Miguel Carrera Zepeda, ING. AGR., Research Aide in Publications
Jesús Martínez Reding Jiménez, PASANTE, Research Aide in Publications
Alfonso Ortega Andapia, PASANTE, Research Aide in Publications
Gil Olmos Barrera, PASANTE, Research Aide in Film Production
Leobardo Briseño Terpan, Assistant in Photography
Juan Zamora López, Laboratory Technician

Field day at the Santa Elena station.

Director's Introduction

Basic food production for the period covered by this report reached the greatest tonnage levels ever achieved in Mexico. The 1959 corn harvest for the second consecutive year was the largest on record with an estimated production of approximately six million metric tons. In addition to favorable climatic conditions the increased yield reflected the greater utilization of improved varieties and hybrids, and proven fertilizer recommendations for the crop, as well as intensive federal campaigns to increase the production of this basic cereal in the most adequate corn production regions of the nation.

The national wheat crop for the past year was essentially the same as for 1958, in spite of the fact that acreage was reduced considerably in irrigated regions of the northwest because of adverse weather conditions at time of planting. In general, however, climatic conditions permitted greater average yields per land unit than are usually experienced and it is very likely that a new average national yield per hectare was established. With a national yield of approximately 1,100,000 tons of wheat for the past year, it is unlikely that it will be necessary to import wheat during 1960.

An unusually dry winter season has been responsible for considerable losses in the livestock industry in the Gulf Coast area. The effect of this general drought may be felt for some time to come and is responsible in large part for the ranchers' increasing enthusiasm for the utilization of grass silage in the Gulf Coast area.

During the summer of 1960 there were strong indications that general crop prospects for this season may not be as satisfactory as during the past two years. A late beginning of the rainy season has already rather seriously affected the prospects for summer corn and bean crops. Cotton acreages for the present year are up over last season and prospects in general point to a bumper crop of cotton, which is produced almost exclusively in the irrigated districts of Mexico.

Early this year it was officially announced by the Minister of Agriculture that a reorganization of agricultural research would take place. In very general terms this would signify a unification of the two organizations at present conducting agricultural research in Mexico, excluding commissions which have been especially charged with the investigation of certain export crops. It is the intention of the Ministry of Agriculture to unify programs and personnel of the Instituto de Investigaciones Agrícolas and the Oficina de Estudios Especiales. In an effort to develop sound plans for such unification based upon national research program needs and existing physical facilities and human resources, several staff members of the OEE have been conducting a thorough study of these phases of Mexican agriculture since February, 1960. It has been found that the minimum requirements both in physical installations and trained technical personnel exist to provide the basis for an adequate national research program in basic food crops.

During the period covered by this report, more than 5,000 farmers, technicians, and officials attended field days held at experiment stations operated by the Office of Special Studies. The impact of these field days on agriculture in Mexico is being reflected not only in increased enthusiasm and interest on the part of the farmers themselves for information about the latest technical advances in crop production but also through the establishment of closer relationships between farmers and ranchers and research and extension personnel in this country; this is leading also to a better understanding of the principal agricultural problems to be resolved.

A special field day was held in August, 1959, for the Minister of Agriculture at the Cotaxtla Experiment Station. Research results and methods were explained and demonstrated to the Minister and his party including Dr. Milton Eisenhower, Dr. Carrillo Flores, and other distinguished guests. In June, 1960, the Minister of Agriculture visited the El Horno Experiment Station at Chapingo in company with President Dorticós and the Minister of Agriculture, Pedro Merit, of Cuba.

During the spring and summer months of 1960 the first group of students from the Graduate Faculty at Chapingo were graduated with the Master's degree. These ten young Mexican scientists now occupy positions of responsibility as professors in the agricultural colleges of Mexico and in several research programs. It is expected that the postgraduate college at Chapingo will continue to produce outstanding young scientists to fill the pressing needs for well-trained men in the fields of education and research in Mexico.

GENERAL ACTIVITIES

Several important changes occurred in staff of the Mexican Agricultural Program during the past year. Sr. Pablo Velásquez, who holds a master's degree in Library Science, joined the program in April, 1959, to directly supervise management and operation of the library of the Office of Special Studies. Dr. Daniel Hagen joined the program as Assistant Animal Pathologist to continue development of the effective research and training program in animal pathology. In January, 1960, Dr. N. E. Borlaug assumed responsibility for the Inter-American Wheat Improvement Project. Dr. Borlaug will continue to headquarter with the Mexican Agricultural Program. In February, 1960, Dr. Ignacio Narvaez assumed full responsibility for the small grains improvement program of the Office of Special Studies. Dr. Eduardo Alvarez returned from postgraduate studies at Cornell University to take complete charge of the horticultural program in June, 1960.

Dr. Nicolás Sánchez was appointed in April, 1960, Technical Subdirector of the Office of Special Studies. For the past four years Dr. Sánchez has been Director of the Northwestern Research Center (CIANO) in the Yaqui Valley.

Dr. R. D. Osler left the Mexican program in June, 1960, to become Assistant Director for Agricultural Sciences of The Rockefeller Foundation in New York. Dr. W. D. Yerkes resigned in July, 1960, to accept a position with a private firm in the United States. Dr. Alfonso Crispín returned from postgraduate studies at the University of California to assume full responsibility for the bean and soybean improvement program.

The loss of Dr. Osler, Dr. Yerkes, and Dr. Borlaug from the research programs in Mexico is serious since their long experience and outstanding ability in their particular fields of research have been responsible for significant advances in Mexican agriculture. Fortunately, however, well-trained Mexican scientists have demonstrated their capacity to carry on and advance the research programs which these men are leaving. These particular staff changes, in addition to the appointment of Dr. N. Sánchez as Subdirector of the Office of Special Studies, during this year represent a partial fulfillment of one of the basic objectives of the program: the development of young Mexican scientists to provide the leadership necessary for resolution of agricultural problems.

TEMPORARY STAFF AND SCIENTIFIC AIDES

The program gratefully acknowledges the cooperation of the Inter-American Institute of Agricultural Sciences in Costa Rica in having made available the services of Dr. Ernest H. Casseres through September, 1960. Dr. Casseres has been in charge of the horticultural research work of the Office of Special Studies pending the return of Dr. Eduardo Alvarez from Cornell University.

Dr. Ralph E. Comstock of the Department of Animal Husbandry, University of Minnesota, was appointed Temporary Scientific Aide November, 1959, for a period of three weeks for consultations on the development of certain long-range maize breeding projects. During that time he also assisted in the development of curriculum in the field of genetics at the Graduate Faculty at Chapingo. Dr. Comstock is a geneticist on the staff of the above-mentioned institution.

Dr. Clyde M. Christensen, Professor of Plant Pathology, University of Minnesota, was appointed Special Temporary Scientific Aide to the Mexican Agricultural Program in September, 1959, for a period of six months. During that time research projects were undertaken concerned with the study of fungi in stored grains. Dr. Donald A. Wilbur's appointment as Special Temporary Scientific Aide concerning studies of and control of insect pests in stored grains was extended for a three-month period beginning January 1, 1959. The outstanding ability of both Dr. Christensen and Dr. Wilbur in the development of sound research programs on stored grain problems has assisted significantly in the training of personnel in this field and in the establishment of programs which will lead to the resolution of the serious national problems concerned with storage of grains in Mexico.

Dr. Barbara McClintock, cytogeneticist at the Carnegie Institution, Cold Spring Harbor, New York, was appointed Special Temporary Scientific Aide to assist in cytological studies of Mexican corn races in cooperation with the Graduate Faculty at Chapingo.

Dr. P. P. Levine, Professor of Poultry Diseases at the School of Veterinary Medicine, Cornell University, was appointed Special Temporary Scientific Aide for a three-month period beginning June 16, 1960. Dr. Levine will assist the Mexican program in studies of avian diseases.

Dr. R. E. Larson, Head, Department of Horticulture, Pennsylvania State University, was appointed Special Temporary Scientific Aide to the MAP for a period of six months beginning July 1, 1960. Dr. Larson will assist in further development of the horticultural program and provide special counsel in the field of plant breeding in the Graduate School at Chapingo.

OTHER VISITING SCIENTISTS

Dr. H. C. Thorpe of the Plant Breeding Station, Department of Agriculture, Ministry of Agriculture, Animal Husbandry, and Water Resources, Kenya, Africa, visited the MAP on a travel grant from The Rockefeller Foundation. He arrived in Mexico in September, 1959, and consulted particularly with members of the small grains improvement program.

Dr. K. L. Turk, Head of the Department of Animal Husbandry at Cornell University and Consultant to the Foundation, spent August and September, 1959, studying the livestock industry in Mexico and its relationship to the MAP.

Dr. E. C. Stakman, Special Consultant to the Foundation's Agricultural Program and professor emeritus of the University of Minnesota, spent approximately six months with the MAP from September, 1959, until April, 1960. Dr. Stakman assisted principally in the development of course work and seminar programs in the Graduate Faculty at Chapingo and consulted with staff members of the MAP.

Dr. David B. Williams, Director of the Foreign Student Office, Cornell University, visited Mexico on a Foundation travel grant. He consulted with staff members of this program and with university and agricultural and technical schools in Mexico concerning the student training program for young Mexicans attending Cornell University. Dr. Williams arrived in March, 1960, and spent one month with the MAP.

Dr. Hugh Doggett of East Africa visited the MAP on a Rockefeller Foundation travel grant to observe the sorghum breeding and utilization program in Mexico during the month of September, 1959.

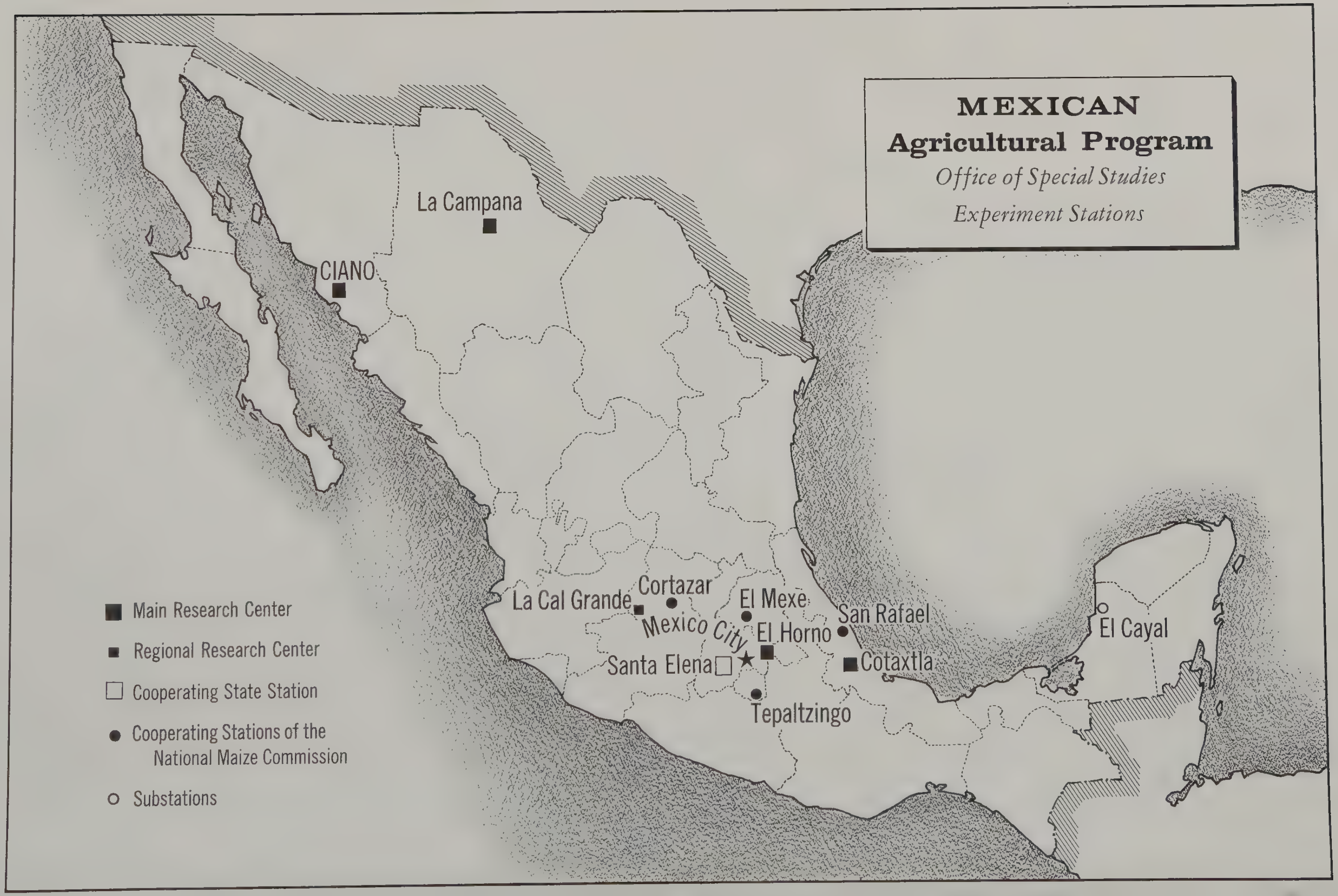
Mr. Michael N. Harrison of Kenya, Africa, also visited the MAP on a Foundation travel grant and consulted with various staff members in this program.

Dr. H. M. Beachell, Research Agronomist, U.S. Department of Agriculture, from Beaumont, Texas, consulted with staff members in charge of the small grains improvement program, particularly with the rice specialists at the Cotaxtla station, in May, 1960.

Dr. Omar E. Sperry, Professor of Range Management at the Texas Agricultural and Mechanical College, visited the La Campana range management station in Chihuahua during May, 1960, to evaluate last year's herbicide trials for the control of plants toxic to livestock.

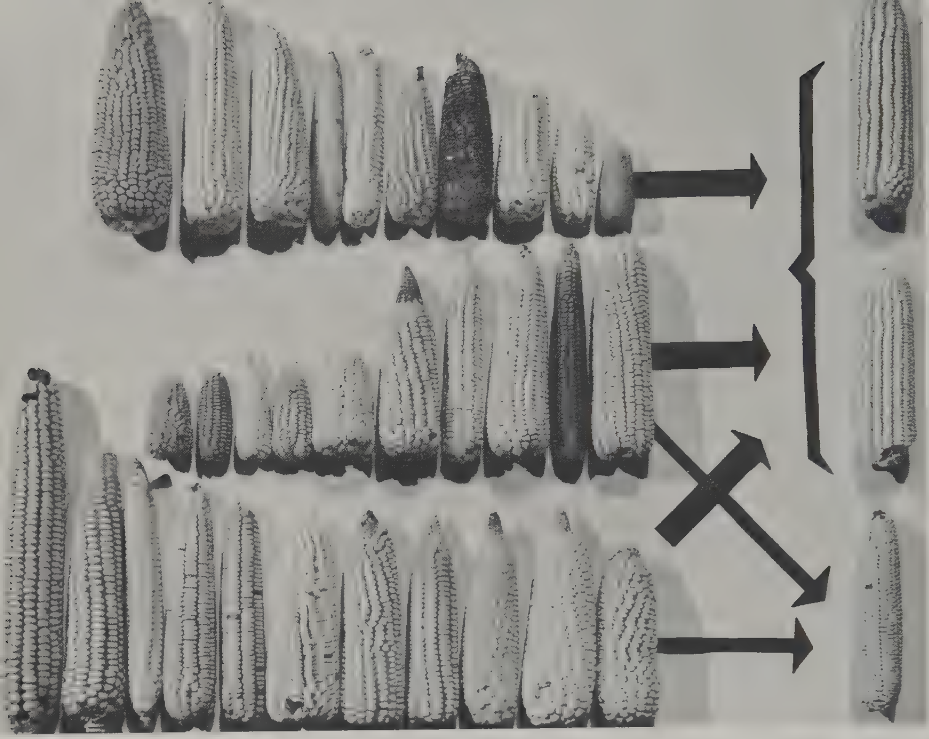
Other visitors to the MAP during the past year included the following scientists and educators who consulted with staff members of the program on an official or semi-official basis:

Mr. S. Hagrase, Technical Director of Agrarian Reform, Cairo, Egypt
Dr. R. G. Shands, U.S.D.A. and University of Wisconsin, Madison
Dr. J. P. Mieners, U.S.D.A., Beltsville, Maryland
Dr. E. B. Hayden, Rust Prevention Association, Minneapolis, Minnesota
Dr. R. G. Anderson, Rust Laboratory, Canada Department of Agriculture, Winnipeg
Dr. Kenneth Lebsock, U.S.D.A., Fargo, North Dakota
Dr. Lysle D. Leach, Professor of Plant Pathology, University of California, Davis
Mr. Willard Lee Stuck, Mennonite Colony, Cuauhtemoc, Chihuahua
Prof. T. C. Allen, Department of Entomology, University of Wisconsin, Madison
Mr. Olen E. Leonard, Director, North Zone, Project 39, O.E.A., Havana, Cuba
Dr. Byron T. Shaw, U.S.D.A., Agricultural Research Service, Washington, D. C.
Dr. T. C. Byerly, U.S.D.A., Agricultural Research Service, Washington, D. C.
Dr. Harry F. Baty, Montana State College, Bozeman
President F. L. Hovde, Purdue University, Lafayette, Indiana
Dr. Eduardo Morales M., Rector, University of Valdivia, Chile
Dr. D. E. Alexander, Associate Professor of Plant Genetics, University of Illinois, Urbana
Dr. S. G. Younkin, Director of Research, Campbell Soup Company
Dr. Fred S. Wyatt, Gerber Baby Food Company, Oakland, California
Dr. Guillermo Gómez M., Dean, School of Agronomy, National University, Santiago, Chile
Dr. Ernest P. Imle and Dr. Leonard Schwarz, American Cocoa Research Institute, Washington, D. C.
Dr. John G. Adams, Associate Seed Growers, Inc., Connecticut
Dr. R. L. Lovvorn, Director of Research, North Carolina State College, Raleigh
Mr. B. P. Tompsett, Plant and Seed Collector for the British Museum and Herbarium, Kew, England
Professor Basil G. Christidis, University of Thessalonike, Greece.


MEXICAN
Agricultural Program
Office of Special Studies
Experiment Stations
La Campana
CIANO
La Cal Grande
Cortazar
El Mexe
Mexico City
El Horno
San Rafael
Santa Elena
Cotaxtla
Tepaltzingo
El Cayal
■ Main Research Center
▪ Regional Research Center
☐ Cooperating State Station
● Cooperating Stations of the National Maize Commission
○ Substations

Experiment Stations of the Office of Special Studies, Ministry of Agriculture, Mexico, and Cooperating Stations.

	Location	Name	Size (acres)	Altitude (meters)	Av. temp. (°C.)	Av. rainfall (inches)	Soil types	Principal fields of investigation	Type of agriculture in region served
MINISTRY OF AGRICULTURE—OEE STATIONS									
Research Center, Mesa Central	Chapingo, México	El Horno	420	2,200	14–15	28	Lacustrean; Volcanic	All OEE programs	Corn, beans, wheat; Poultry; Dairy
Research Center, the Bajío	La Piedad, Michoacán	La Cal Grande	278	1,650	19	20–36	Lacustrean; Volcanic	All OEE programs	Corn, beans, wheat, vegetables; Dairy
Research Center, Tropical Zones	Veracruz, Veracruz	Cotaxtla	305	9	24	65	Alluvial; Residual	All OEE programs except wheat	Corn, rice, beans, fruit, sugar cane; Range cattle
Substation, Tropical Zones	Campeche, Campeche	El Cayal	240	30	24	36	Alluvial; Residual	Corn, sorghum, beans; Forage crops; Soils	Corn, beans; Range cattle
Research Center, Northwest	Cd. Obregón, Sonora	CIANO	240	25	26	8	Desert	All OEE programs	Irrigated corn, wheat, vegetables, cotton; Oilseed crops
Experimental Range Station	Chihuahua, Chihuahua	La Campana	2,774	1,450	17	6	Desert	Forage crops; Animal science	Irrigated cotton; Beef cattle
STATE OF MEXICO—OEE STATION									
Research Station, High Altitudes	Toluca, México	Santa Elena	120	2,700	12.5	36	Alluvial; Volcanic	All OEE programs	Corn, small grains, beans, potatoes; Livestock
COOPERATING STATIONS									
National Corn Commission Stations									
Bajío Station	Cortazar, Guanajuato	Cortazar	197	1,750	20.4	26	Lacustrean; Volcanic	Corn and sorghum breeding; Basic seed production	(As La Cal Grande)
Tropical Corn Station	San Rafael, Veracruz	San Rafael	36	10	26.8	67	Alluvial	Basic seed production	(As Cotaxtla)
Tropical Corn Station	Tepaltzingo, Morelos	Tepaltzingo	300	1,150	22.1	34	*In situ;* Volcanic	Seed production; Inter-American corn program	Corn, rice, beans, vegetables, sugar cane
State of Hidalgo Station									
State Station	El Mexe, Hidalgo	El Mexe	120	1,900	16.3	17	*In situ;* Volcanic	Wheat and corn breeding	Irrigated corn, wheat, barley, alfalfa, vegetables; Temporal corn, barley; Maguey



Thirty-one native races of maize and the three testers used with them. (See page 30.)

Corn

1959 As a Commercial Corn Year

The largest corn crop in Mexico's history was harvested in 1959, according to all reports. Although estimates of actual tonnage produced vary considerably, the tremendous problems which occurred in selling and storing the crop, plus the sizable amounts which were exported, clearly emphasize that the 1959 production was substantially above that of any previous year. Although man-controlled factors of good seed, fertilizers, and cultural practices contributed their annually increasing shares, the primary factor involved in this heavy production was the fact that rainfall was more nearly adequate, both in amount and in distribution, than in most years. The only region of Mexico where corn suffered from drought to any considerable extent in 1959 was in north-central Mexico, including parts of the States of Chihuahua, Coahuila, and Durango.

The economic and storage problems which occurred with the large production in 1959 constitute a major stumbling-block to increasing annual corn production in Mexico to a level where it can keep pace with the growing population. Although the price of corn is supported by the federal government, many farmers had to sell their corn to private buyers at reduced prices owing to need for cash and lack of storage space on the part of both farmers and the government agency officially charged with buying the corn. This market weakness makes farmers who can grow other crops reluctant to grow corn, and also discourages increased production by those who could and would grow more with greater profit incentive. A certain degree of diversion to other crops may well be justified in particular areas. Such conditions, however, do not help to stabilize, or increase, corn production in line with growing national needs.

BRIEF DESCRIPTION OF THE BREEDING PROGRAM

At the present time the corn improvement program is divided into four distinct subprojects centered at Cotaxtla, Cortazar, CIANO, and El Horno. The four subprojects have in common a general goal of improvement of the corns now recommended for the region the station was developed to serve. The broad objectives of each will be presented separately.

COTAXTLA

Improvement of corn for the humid tropics of Mexico, including parts of the States of Veracruz, Tamaulipas, Tabasco, Campeche, Chiapas, and Nayarit. Specific characters involved in the improvement of the hybrids presently recommended (H–501, H–503, H–504) within these humid, tropical regions are: (1) reduced height; (2) lower ear placement; (3) resistance to corn stunt; (4) resistance to insect attack; (5) resistance to *Helminthosporium;* (6) better shuck cover of the ear; and, of course, (7) higher yield. Another broad objective is the development of high-yielding corns, earlier in maturity than the hybrids now available. Such corns are needed for a rather large area within that part of the humid tropics where late corns are not well adapted owing to lack of moisture, shortness of annual rainfall period, or other environmental conditions.

CORTAZAR

Improvement of corn for the intermediate altitudes of Mexico, including the Bajío and adjacent regions of similar altitude and climate. In recent years this subproject has been centered at the La Cal Grande station, near La Piedad, Michoacán, but in 1959 the work was transferred to the National Corn Commission fields adjacent to their plant near Cortazar, Guanajuato. As soon as possible this subproject will be centered at the new research center El Roque, near Celaya, Guanajuato. The improvement of the corns presently available for natural rainfall plantings involves the development of corns with greater resistance or tolerance to drought. This will necessitate a much more extensive off-station testing program than in the past in order to isolate the corn germ plasm best adapted to the wide range of environmental conditions which prevail in this region. Cooperative work is now planned in an effort to compare sorghum and corn in this rather large, marginal rainfall region, since it seems very possible that sorghum might be a better crop in much of the area because of its greater drought resistance. The other principal program within this subproject involves the development of high-yielding, disease-resistant (particularly to head smut, incited by *Sphacelotheca reiliana*) corns adapted to irrigated plantings.

CIANO

Improvement of corn for the dry, hot climates of northern and northwestern Mexico. Begun in 1955, this subproject is still largely limited to the Yaqui Valley. With new improved corns now becoming available from this subproject, it is hoped that facilities can be expanded so that the corn breeding work under way at CIANO can become effective over a much larger region. Experience within this subproject has brought about the initiation of two separate breeding programs. The objective of the first is to develop short-season corns which, when planted in the spring (April), can escape the disastrous effects of high temperatures encountered when the presently available late corns, such as H–501 and H–503, are planted at that time. The second breeding program is directed toward long-season corns, similar to H–501 or H–503 but better able to withstand the insect pests and diseases which are now problems in fall plantings.

EL HORNO

Improvement of corn for elevations above 1,900 meters in central Mexico. This subproject serves three somewhat separate altitude zones: 1,900 to 2,100 meters, 2,000 to 2,400 meters, and higher than 2,400 meters. In general, there is a need within each zone for early corns to be planted with natural rainfall and for late corns to be planted with irrigation.

Although very good improved late corns are available for irrigated plantings in almost the entire range of altitude, considerable work still needs to be done on developing corns for natural rainfall plantings. In order to advance this aspect of the program, it is planned to initiate in 1960 a fairly extensive off-station testing program in cooperation with the State of México, the National Corn Commission, the federal Extension Service, and the National School of Agriculture at Chapingo. Such a program is necessary for two reasons: (1) to help orient the plant breeders as to the types of corns needed by the farmers in this extremely variable area, and (2) to determine which, if any, of the large number of experimental corns now in the breeding program are of potential value. Many of these experimental corns involve large differences in certain characters, and too rigid selection at the stations now available could very well eliminate germ plasm of great value for other, slightly different areas within this region.

OUTSTANDING RESULTS IN 1959

COTAXTLA

Combining Ability Between Mexican Tropical Corns and Others of Diverse Origin

The two most widely adapted tropical corns in Mexico—the productive Tuxpeño race from the Gulf Coast and the somewhat less vigorous Vandeño race from the Pacific Coast—were selected as topcross tester parents for the 25 Mexican races plus 6 others from Guatemala. In addition, the Iowa Stiff-Stalk Synthetic (germ plasm from the center of the United States corn belt) developed by Dr. G. F. Sprague, was used to cross with 21 of these same races.

The picture on page 28 shows ears considered to be typical of the race under average production conditions. The three ears on the right are (top to bottom) Tuxpeño, Vandeño, and Stiff-Stalk Synthetic; the groups on the left are the races crossed to the different testers. It can be seen that these races represent a wide range of ear shape, ear size, kernel shape, and texture.

The crosses between the races and the three testers were grown in yield trials at Cotaxtla in 1958 and at San Rafael in 1959. The principal concept to be gained from study of the statistical analyses of the data obtained is that although the first order interactions were not significant, the second order interaction was; that is, certain specific crosses reacted differently at the two locations. An interesting point concerns the testers. Even though Stiff-Stalk Synthetic is relatively poorly adapted to the Mexican tropics, it is better adapted than most of the high-altitude Mexican races and, in addition, gave ratings of the 18 races tested at both locations similar to those of Tuxpeño and Vandeño. Correlations calculated among the three groups of crosses and of the crosses with the parental races support this conclusion. Yields of the races themselves were also fairly good indicators of the value of the various races in crosses to the three testers.

Another interesting result was that of the five top-yielding races in the crosses, three (Harinoso de 8, Chapalote, and Nal-tel Amarillo) are considered "primitive" or ancient races. The other two (Tepecintle B and Tabloncillo) are more "modern," but are not considered among the most productive or desirable agronomically as races. These data, together with study of the F_2 at Cotaxtla and San Rafael, have led to the conclusion that significant advances can be obtained in yield as well as in certain agronomic characteristics from previously unused Mexican and, very probably, other corn germ plasm.

A New Late Hybrid (*H-507*)

H–507, a new late hybrid, has been evaluated in numerous yield trials at Cotaxtla and San Rafael and at 11 locations throughout Central America. Comparative yield data for H–507 and the presently recommended hybrid, H–503, are given in Table 1.

As shown in the table, H–507 had an average advantage of 21% over H–503. These data, as well as information obtained from a sizable number of demonstration plantings in

TABLE 1.

Comparative yield data for H-507 and H-503. 1958–1959.

Hybrid	1958 Cotaxtla	1958 San Rafael	1959 Cotaxtla	1959 San Rafael	1959 Central America	Weighted average
H-507	4,550[a]	5,850	3,875	4,900	3,776	4,220
H-503	3,650	4,200	3,200	4,675	2,601	3,502
No. trials	4	1	18	12	11	

[a] Kg./ha. of shelled corn at 15.5% moisture.

the southern part of the State of Veracruz, have led to plans for the release of H–507 to farmers. More experience is needed, however, before it can be said that this new hybrid will completely replace H–503.

CORTAZAR

Head Smut in Irrigated Corn

Head or tassel smut, incited by *Sphacelotheca reiliana*, was first noted as a serious problem in 1958 irrigated plantings. A cooperative project to study this problem was initiated in 1959. Some of the more important findings, from the standpoint of breeding resistant corns, are listed below.

(1) Some 30 S_1 lines derived from H–353, V. S. 5, and Oaxaca 10 have been either highly resistant or nearly immune in three different observations—as lines at La Cal Grande in 1958, as lines at Cortazar in 1959, and in topcrosses at Cortazar in 1959.

(2) Although H–353 was again the most susceptible of the hybrids developed for the region, it was no more susceptible than the widely grown native variety Celaya.

(3) While most of the basic lines now used in the recommended commercial hybrids proved to be relatively susceptible, two (BI 82–2–3 and Gto. 20–247–2–2–4–5) appeared highly resistant.

(4) Of a large number of collections which originated in the States of Querétaro, Guanajuato, Michoacán, and Jalisco, several appeared to offer considerable resistance.

(5) With later dates of planting, rates of infection were lower—a definite reversal of the information obtained in 1958 and included in last year's annual report. A careful study of the pathogen is needed, covering temperature and moisture conditions of spore germination.

Value of Exotic Mexican Corn Germ Plasm Planted with Irrigation

As a part of the over-all plan to obtain preliminary information on the value of exotic corns in the Mexican breeding program, all possible crosses among three high-plateau corns, three Bajío corns, and three from the tropics were obtained and evaluated in yield trials in the Bajío in 1959. Ten of these crosses equaled or exceeded the yield of the hybrid presently recommended for this area, H–353. One cross (Criollo de Ixtacalco × V–520–C) yielded 27% more than H–353.

Although these trials must be repeated before conclusions can be drawn, it is interesting to note that the best crosses for this intermediate-altitude region were those between races adapted to high altitudes (Chalqueño or Cónico) and a race adapted to the low altitudes (Tuxpeño). This study will be enlarged in 1960 to include parents, F_1, F_2, and both backcrosses.

CIANO

Although corn has an ancient history in the northwestern coastal region of Mexico, until 1955 it was not considered an economic crop in the irrigation districts. The small area planted to corn was largely that of the

Ears of H-507, a new hybrid developed for cultivation in the humid tropics of Mexico.

ejidatarios and yielded very little owing to poor cultural practices and the use of low-yielding varieties.

Beginning in 1956, the area planted to corn and average yield obtained have increased considerably through the introduction of improved corns and improved cultural practices, as well as a demand on the part of the farmers themselves for a greater diversification of crops. Agricultural specialists in the States of Baja California, Sonora, and Sinaloa are estimating that the area planted to corn may ultimately reach 250,000 to 300,000 hectares. This is in contrast to an average of approximately 130,000 hectares for the period 1955–1957. The area clearly possesses the facilities of soil, climate, and irrigation water to contribute a large and relatively stable annual production that is badly needed in Mexico.

A New Early White Hybrid (*H-412*)

Experience at CIANO has indicated the need for a short-season corn to replace the late hybrids H–501 and H–503 which, when planted in the spring, are disastrously affected by high temperatures encountered during pollination. On the basis of performance predicted from two years of single-cross data (Table 2), H–412 will probably fill this need.

Since spring cycle data on the actual double cross will not be available until June, 1960, it is not possible to recommend the new hybrid to farmers at present. Although preliminary data indicate that a number of newer experimental combinations are considerably better than H–412, the latter will be used as an interim release if 1960 data so warrant.

EL HORNO

A New Combination of Germ Plasm For the Higher Altitudes

In 1956 the yield trials at El Mexe, Hidalgo (1,900 meters elevation), included hybrids developed at other centers. Among these hybrids was one now known as H–353, which is recommended for early irrigated plantings in the intermediate altitudes (1,400 to 1,750 meters elevation). This hybrid actually yielded less than much of the other material in the trials but was virtually free of disease problems of both ear and plant—particularly stalk rot, an important disease in this region. This apparent resistance to stalk rot led to the crossing of some 100 S_1 lines out of H–353 to: (1) two single crosses adapted to El Horno conditions (2,250 meters elevation), and (2) the best open-pollinated variety in the vicinity of El Mexe. Certain of these crosses were outstanding agronomically in both 1958 and 1959, and outyielded the recommended hybrid by 50% to 64%. On the basis of the data obtained, an extensive testing and demonstration program is planned for 1960.

The results at El Mexe in 1958 led to the inclusion of some of these crosses in yield trials at El Horno in 1959. Data on four of the crosses are given in Table 3.

Although yields and agronomic data were outstanding, considerably more information

TABLE 2.

Yield and agronomic data of H-412 predicted on the basis of two years' single-cross data. Spring plantings, 1958–1959.

Hybrid or variety	YIELD Kg./ha.[a]	YIELD % of V-401	RATINGS[b] Ears	RATINGS[b] Plants	RATINGS[b] Lodging
H-412	5,271	129	2.7	2.8	1.8
V-401	4,075	100	3.1	2.8	1.9

[a] Shelled corn with 15.5% moisture.

[b] Scale of 1=good, 5=poor.

is needed on dates of planting before hybrids involving the lines from H-353 can be considered for recommendation. The experimental hybrids and the lines themselves averaged from 15 to 20 days later than the recommended hybrid H-125 and might suffer frost damage during their longer growing season.

Evaluation of S_1 and Derived S_6 Lines

Reports from other workers, as well as information available from the Mexican breeding program, have indicated that early testing permits the isolation of high combining, early generation lines. This knowledge led to the development and release of hybrids involving S_1 lines. The purpose was twofold: (1) to get higher-yielding corns to the farmers within a relatively short time, and (2) to provide the many farmers who would plant F_2 seed with hybrids having a lower expected yield loss in advanced generations. Although it has been possible to maintain the yields of such hybrids, their production has been somewhat difficult in certain cases because of the variability associated with S_1 lines. In recent years the tendency has been to utilize more highly inbred, and therefore more uniform, lines.

To obtain information on the type of tester that should be used, a two-part study was initiated. In part A, 11 pairs of lines, each pair consisting of an S_1 line and its derived S_6 line

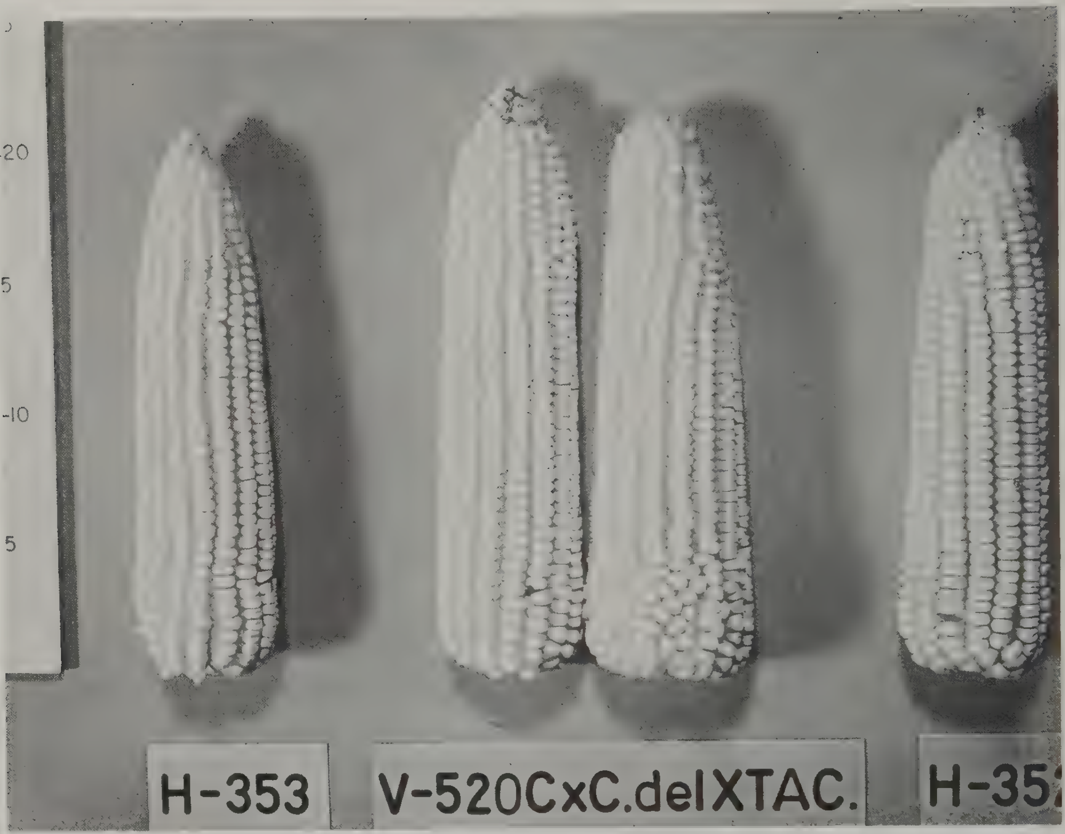
TABLE 3.

Yield and agronomic data of four new experimental crosses planted with irrigation. El Horno, 1959.

Hybrid or variety	YIELD Kg./ha.[a]	YIELD % of Chalco	% Dry matter	RATINGS[b] Ears	RATINGS[b] Plants	RATINGS[b] Lodging
(M8 × M7) × H-353-92	12,870	217	72	2.2	1.2	1.2
” × -87	12,486	211	71	2.5	1.9	1.2
” × -84	10,958	185	74	2.9	2.4	1.4
” × -93	10,591	179	72	3.1	2.0	1.1
H-125	9,712	164	76	3.0	3.1	1.1
Chalco	5,925	100	78	4.1	3.5	1.5

[a] Shelled corn with 15.5% moisture.

[b] Scale of 1=good, 5=poor.



Comparison of the best intervarietal cross and the two hybrids currently recommended for plantings in the Bajío.

(by visual selection only), were crossed to 6 testers. The testers were: an open-pollinated variety (Mex. 37) and S_1, S_3, and S_6 lines derived from it, and single crosses of $S_1 \times S_1$ and $S_4 \times S_4$ lines from the same variety. In part B, 6 of the same 11 pairs of lines used in part A were crossed to 4 testers: an open-pollinated variety (Mex. 39) and S_1, S_3, and S_5 lines from this variety. Mexico 37 and Mexico 39 differ considerably in maturity but are otherwise essentially similar corns from the same general area of Mexico.

The analyses of variance for yield of the two experiments indicated that although generations were significantly different in part A and not in part B, when only the six pairs of lines common to both experiments were considered, generations were not significantly different. Apparently the significant variance for generations in experiment A was due to the five pairs of lines not included in experiment B. The interaction, source of lines × generations, was highly significant in both experiments. This result is similar to that obtained in earlier studies of similar germ plasm.

The two interactions—source of lines × testers, and testers × generations—were the important ones in this study. In the former the testers were varying in degree of homozygosity, while in the latter both testers and lines being tested were varying in degree of homozygosity. The conclusion drawn is that any one of the six testers in experiment A or the four testers in experiment B rated the line sources and generations the same. Such a result differs considerably from most of the data on this problem published in the United States. The explanation probably lies in the diversity of germ plasm involved. Whereas the studies in the United States essentially involved one race, the corns in these experiments involved germ plasm from 3 races, which include in their ancestry at least 11 of the 25 Mexican races.

The data just discussed seem to indicate that within each experiment the rating of the lines or of the generations was not significantly affected by increased homozygosity of the tester.

Correlations were calculated of S_0, S_1, S_3, and S_6 generations of Mexico 37 versus the S_0, S_1, S_3, and S_5 generations of Mexico 39, using the six pairs of lines common to both parts of the study. The results are given in Table 4.

TABLE 4.

Correlations between early versus late testers.

Generation of tester	df	r values
S_0 vs. S_0	10	+0.65[a]
S_1 vs. S_1	10	+0.78[b]
S_3 vs. S_3	10	+0.44
S_5 vs. S_6	10	+0.53

[a] $P < .05$ [b] $P < .01$

The significant r values for S_0 versus S_0 and S_1 versus S_1, and the non-significant r values for S_3 versus S_3 and S_5 versus S_6 indicate that combining ability for yield was significantly changed by inbreeding.

From the data obtained in this study, it is apparent that: (1) there is need of critical data comparing the tester problem within a single race, as well as between races, and (2) methods or techniques developed in the United States on a relatively narrow range of germ plasm may not be directly applicable to other corn breeding programs such as that in Mexico, where the variability of germ plasm being utilized is much greater.

Seed production field of the hybrid, Texas 620.

Sorghum

Sorghum production in Mexico reached an estimated 105,000 hectares (roughly 260,000 acres) in 1959, with an average yield reported of 2.2 metric tons per hectare (approximately 1,965 pounds or 39.3 bushels per acre). Production has been increasing more or less regularly each year since 1955, when 55,000 hectares were planted.

The ability of sorghum to withstand drought and the unfavorable rainfall distribution so characteristic of much of Mexico, makes it a logical and extremely promising addition to the country's cereal supply. Although the potential sorghum production of Mexico is still largely unrealized, the livestock feed industry is now developing and beginning to use sorghum; a somewhat stabilized price has been established in the market, an indication of acceptance of the grain; and cultural practices and varietal recommendations that have been developed are being put into use by producers.

Most of the sorghum now in production in Mexico came directly as introductions from the United States. Many varieties were introduced and established in observational plantings in areas that appeared suitable throughout the country. Continuation and repetition of trials of promising varieties within the different areas have made possible varietal recommendations for major areas. The need for a varietal improvement program quickly became apparent since conditions in Mexico differ widely from those under which selections and improved varieties were developed in the United States.

The sorghum program is now oriented with the following general concepts: (1) earlier varieties are needed for much of the production area; (2) varieties must be developed for areas above 1,800 meters elevation; (3) a comparison of corn and sorghum returns needs to be made in many marginal areas of corn production to better delineate the areas for which each may be recommended; (4) seed sources and supplies of recommended varieties must be developed; and (5) the educational and demonstration program on production and uses of sorghum must be intensified.

Because of limitations of funds and trained personnel, the breeding program begun in 1957 was transferred almost entirely to the Bajío area in June of 1959. Part of this work had been in progress at the CIANO station, where only yield tests will be continued. In addition, more intensive studies were initiated with the idea that as sorghum production expands in Mexico, additional personnel and stations will be needed to keep pace with the importance of the crop.

RESULTS IN THE BAJIO

YIELD TRIALS

Grain Sorghum

Yield and agronomic data were obtained from 4 experiments involving some 65 hybrids and varieties. The data for the six best entries, shown in Table 1, indicate that Texas 660 was slightly superior among the hybrids and that Kafir 60 gave the highest yields among the varieties.

These data have led to the conclusion that, with the possible exception of Texas 660, none of the hybrids presently available from United States breeding programs are significantly better under Bajío conditions than Kafir 60, the female parent of each of the hybrids and the variety presently recommended within the Bajío region.

Forage Sorghum

Six forage varieties were included in a trial to study the effect of date of harvest on yield. These were harvested on 4 dates at 13-day intervals. The first date of harvest coincided with the end of flowering, and the last date of harvest was that of mature grain. The results may be summarized as follows:

On the average, all six varieties had attained maximum yield of green forage by the first date of harvest. Maximum yields of dry weight were attained by the third date of harvest (grain in dough stage). The six varieties ranked as to forage yield at the dough stage in the following descending order: Sumac, Tracy, Orange, Honey, White African, and Cane Sugar Drip.

Inclusion of these data in a four-year summary indicated that Sumac was the highest-yielding forage variety for Bajío conditions.

TABLE 1.

Yield data of the six highest-yielding grain sorghums at three locations. Bajío, 1956–1959.

Variety or hybrid	La Piedad, Mich. 1956	La Piedad, Mich. 1957	Pastor Ortiz, Mich. 1957	Cortazar, Gto. 1959	Weighted average	% of Kafir 60	Days to flower
Texas 660	–	6.6[a]	5.4	7.4	6.1	113	81
" 620	4.8	6.4	5.2	6.6	5.8	107	81
Kafir 60	4.5	5.2	–	6.8	5.4	100	81
R. S. 590	4.7	5.2	4.2	6.4	5.1	94	75
Kafir 1	3.6	4.3	4.9	5.7	4.6	85	82
Redbine 2	3.7	5.0	4.8	4.7	4.6	85	84
L.S.D. (.05)	0.6	0.9	0.9	1.0			

[a] Ton/ha. of grain with 12% moisture.

Broomcorn

Six varieties of broomcorn were included in a trial to study the effect of time of harvest on yield of fiber. The four dates of harvest were the same as those described in the forage trial. The results from this trial were as follows:

Yields of air-dry brush increased significantly at each succeeding date of harvest, at least part of this increase being due to the inclusion of late-maturing tillers at the later dates of harvest. The six varieties ranked in decreasing order of yield of air-dry fiber (mature grain stage) as Scarborough, Black Spanish, Austrian, White Italian, Acme, and Okaw. Even though the yields of air-dry fiber were relatively high, the quality was generally poor.

SURVEY IN GUANAJUATO

A survey of commercial sorghum production was made in the area generally bounded by the cities of Silao, Irapuato, Pénjamo, Valle de Santiago, and Cortazar. Average yield of grain over all areas was 2.37 ton/ha., or slightly higher than the national average (based on 19 locations). It was estimated that at least a 50% increase in yield could be obtained by planting sufficient good-quality seed to attain adequate plant populations. Farmers themselves reported that very few planted certified seed of known germination or applied fertilizer, and none treated their seed with fungicides against seed-rotting fungi and common smut.

BREEDING PROGRAM

High-Yielding Adapted Hybrids

Twenty-six "A" lines and their corresponding "B" lines have been introduced for use in the breeding program. This material represents germ plasm derived from the varieties White Wheatland, Resistant Wheatland, Westland, Martin, White Martin, Redlan, Reliance, Redbine 60, Combine Kafir, and eight yellow endosperm selections. With this material as a basis, 627 crosses between male-sterile lines and grain-type varieties or selections known to be well adapted to Mexican conditions, were obtained in 1959. In addition, 59 crosses of male-sterile × forage sorghum and 29 crosses of male-sterile × broomcorn types were obtained. Besides classification as to type of line (A or B), these crosses will be observed for possible use as future hybrids.

Some 140 new hybrids were obtained in 1959—crosses between 18 restorer lines from the United States and male-sterile lines selected under Mexican conditions. These will be planted in yield tests in 1960.

Incorporation of Quadruple Dwarf Characteristic

Most of the combine-type sorghums are recessive for three of the four major factors controlling height. An important problem in seed production is the fact that one of the four pairs of alleles is unstable and mutates to the dominant or tall condition approximately 1 in every 1,200 gametes. The quadruple dwarf height is too short to be acceptable to farmers. However, conversion of unstable varieties or lines to the quadruple dwarf condition followed by selection of the tall mutants (these would be triple dwarfs) would possibly eliminate the unstable height in seed production. Accordingly, a backcrossing program using the quadruple dwarf as the nonrecurrent parent was initiated in 1958 in an effort to: (1) introduce exotic germ plasm (primarily high-yielding grain-forage types from India) into combine-height grain varieties; (2) stabilize the height of high-yielding grain varieties and lines to be used in hybrid combinations; (3) reduce the height of common, well adapted broomcorns; and (4) develop better adapted, higher yielding, double-purpose combine varieties.

SPECIAL STUDIES

Relationship of Weight of Grain Per Head To Total Weight of Head

Limited data obtained in 1955 indicated a highly significant correlation between weight of grain per head and total weight of head. Such a correlation, if true and relatively stable, could greatly simplify harvesting of small plots for yield determinations. Two

Crossing block for incorporation of the quadruple dwarf characteristic.

years' data are now available on these two characteristics from 38 sorghum varieties including grain, forage, and broomcorn types. Analyses of the data indicate that:

(1) All heads within a given variety and a given planting have almost identical percentages of grain by weight. (2) The percentage of grain in the head may vary significantly among varieties and between years. (3) The grain/head relationship for different types of sorghum (forage, grain, broomcorn) differs greatly. (4) Within a particular year a sample of 20 heads will give a reliable estimate of the grain/head relationship for at least a given variety at a particular location.

A New Insect Problem

For the first time a rather widespread infestation of a stem borer was observed in the Bajío in 1959. An unidentified white larva, 5 mm. in length, was found in the stem of all types of sorghum. The fact that only the larval stage was found suggested that the insect left the plant at this stage. Counts were made in main stems and tillers of the number of internodes with galleries.

Analysis of the results indicated a highly significant correlation between the percentage of attacked internodes of the main stem and the percentage of attacked plants within a variety. Certain varieties (Shallumex I, Sumac, Cane Sugar Drip) appeared to be somewhat resistant. There was a highly significant difference between percentage of main stems and percentage of tillers attacked within a particular variety. Damage appeared to be greater on those varieties having smaller diameter stems.

Results at Ciano

GRAIN SORGHUM YIELD TRIALS

Data for the 10 best entries in a yield trial (1959 A) that included 18 varieties and 12 hybrids are summarized in Table 2. These sorghums, although in slightly different order than shown in the table, have been the highest yielders in previous tests at CIANO.

TABLE 2.

Yield and agronomic data of 10 highest-yielding grain sorghums. CIANO, 1959 A.

Variety or hybrid	Yield (ton/ha.)[a]	DAYS TO: Flower	Hard grain	Plant height (m.)
Texas 610	6.8	71	106	1.1
De Kalb E 56-A	6.8	75	110	1.1
Redbine 2	6.6	77	112	1.1
Texas 620	6.6	77	111	1.2
De Kalb D 50-A	6.6	68	106	1.2
Amak R-10	6.5	76	108	1.0
Amak R-12	6.4	77	112	1.0
De Kalb C 44-A	6.3	70	107	1.0
C. Hegari I	6.2	71	106	0.9
NK 135	6.1	66	106	1.2

[a] Grain with 12% moisture.

Table 3 summarizes data on the eight best entries in a yield trial planted in 1959 B. This trial included 7 varieties and 13 commercial hybrids.

On the basis of the data presented in Tables 2 and 3, as well as data obtained in other

TABLE 3.

Yield and agronomic data of eight highest-yielding grain sorghums. CIANO, 1959 B.

Variety or hybrid	Yield (ton/ha.)[a]	DAYS TO: Flower	Hard grain	Plant height (m.)
De Kalb D 50-A	8.8	59	100	1.3
Texas 610	8.2	56	101	1.1
C. Hegari II	7.9	56	103	1.1
NK 135	7.9	57	102	1.0
C. Hegari I	7.5	62	104	1.1
DD Milo 38	7.3	59	101	1.1
De Kalb F 62-A	7.3	57	101	1.1
De Kalb F 63	7.2	62	104	1.2

[a] Grain with 12% moisture.

years, and taking into account availability of seed, C. Hegari I, Texas 610, Texas 620, Amak R–10, Amak R–12, and NK 135 have been recommended for the Yaqui Valley.

OPTIMUM ROW SPACING AND DENSITY OF POPULATION

Three years' data from this study indicate that in only one year (1959 A) were there significant differences in yield due to row spacing or plant population. In 1959 A, with the varieties C. Hegari I and Amak R–12, significantly higher yields were obtained with a row spacing of 60 cm. and 5 cm. between plants within the row. In this study, row spacing ranged from 36 to 92 cm. and distance between plants from 5 to 20 cm.

TWO HARVESTS FROM ONE PLANTING

In 1957 a date-of-planting study was initiated to determine the feasibility of and the optimum date for seeding to permit two harvests of grain from the same planting. Study of the three years' data now available indicates that it is possible as well as feasible to obtain two harvests from a single planting. Total yield from two harvests at the optimum date of planting reached 10 ton/ha. of grain with 12% moisture. The optimum date of seeding for obtaining two harvests from a single planting was March 1 to April 1.

Relative height of a normal and a dwarf variety.

Wheat

Upon termination of the present agricultural cycle (1959–1960) national production will be somewhat over 1,100,000 tons, essentially the same as that obtained in the previous cycle. This production will be sufficient to cover the increasing demand, and possibly there will be no need to import grain, as was deemed necessary earlier in the season.

The total area planted to wheat within the country was approximately 750,000 hectares, or 125,000 hectares less than last year. Constant and abundant rains during December and January greatly affected the Northwest by delaying the plantings and lowering the emergence of seedlings. There was also serious frost damage in the northern parts of Guanajuato, Hidalgo, Puebla, Chihuahua, and Coahuila.

In general, however, climatological conditions were very favorable, and it is estimated that yields established a new record of national average. From an average of 1,450 kg./ha. in the 1958–1959 cycle, yields will increase in this cycle to approximately 1,600 kg./ha. and possibly as high as 1,650 kg./ha. These increases in unit yield are due, not only to the prevalence of favorable climatological conditions, but also to a better cultural practice. With the exception of isolated regions in the States of Michoacán, Jalisco, and Coahuila, throughout the country cultural practices have been almost entirely modernized. It can be said that with the adoption of better cultural practices in all the wheat-producing regions, and with the use of new varieties with yielding ability superior to Lerma Rojo, such as Nainari, Andes, and a few dwarf varieties, national production may continue to increase considerably without the need of an expanded area planted to this crop. Yields may easily be increased to 2,000 kg./ha. in not over five years.

The ability of Lerma Rojo to produce high grain yields has augmented its popularity among farmers to such an extent that from 80% to 85% of the wheat from the present harvest will consist of this variety. This situation, although favorable to the farmers, since it offers a better return on investments made, may make it very difficult for the wheat industry to obtain the different flours required. The solution to this problem will depend not only on a genetic program in improvement, but also on studies and plans on the part of the milling and baking industry, and extension and credit groups in cooperation with research programs. It is necessary and urgent to make every effort to maintain a satisfactory balance in the production of hard- and soft-textured wheats.

PRODUCTION BY AREAS

NORTHWEST

Climatic Conditions

Although heavy and frequent rainfalls during December and January retarded a good percentage of the growth, climatic conditions in the coastal region were generally very favorable for the normal development of wheat plants, and yields are expected to be over 2,200 kg./ha., a considerably higher average than a year ago.

Varietal Performance

It is estimated that Lerma Rojo constituted between 80% and 85% of the total area planted to wheat in Baja California, Sonora, and Sinaloa. Its yields continue to be above those of all other varieties grown, and this season it was common to observe fields with yields of 3,500 kg./ha. or more. A heavy infestation of aphids (*Macrosiphum granarium* Kirby) caused serious losses last year, but during the current cycle this pest was efficiently controlled by means of insecticide applications. Although Lerma Rojo is susceptible to the prevalent races of leaf rust (*Puccinia triticina*), this disease did not develop sufficiently to reduce yields.

Yaqui 54 occupied second place in the Northwest—probably around 10% of the total area planted to wheat. While its yields continue to be inferior to those of Lerma Rojo, nevertheless they are much higher this year than last, largely because of the timely control of aphids. Leaf rust, to which this wheat is susceptible, did not cause appreciable reductions in yields, and Yaqui 54 continues to offer resistance to the common races of stem rust. A reselection of Yaqui 54, resistant to brown necrosis and designated "Yaqui 54A," is now in multiplication and will be at the disposal of farmers in the Northwest within the next two years. Efforts will continue to increase plantings of this variety and Gabo 56, since their milling and baking characteristics are urgently required by the industry.

The remaining 5% to 10% of the production in the Northwest is represented by Gabo 55, Yaqui 50, Toluca 54, Yaktana, Barrigón, and Ramona. Verano and Constitution also occupied an area of approximately 5,000 hectares in this cycle. All these varieties yield less than Lerma Rojo.

Pests

The timely intervention of the Bureau of Plant Protection and the local farmers' organization in the Yaqui Valley during the present cycle reduced losses from both aphids and rats to a minimum. As a result of the eradication campaign initiated in February, it was possible to eliminate rats almost entirely.

The damage caused by aphids during the 1958–1959 season was convincing proof to many Sonora farmers that this insect can severely reduce yields, and this season the farmers acted promptly to control the pest. Nevertheless, since aphids reach epidemic proportions in this region only once in every seven or eight years, continued stress must be laid on the importance of farmers' inspecting their fields each year and, when ecological conditions favor the development of epidemics, applying insecticide opportunely.

Diseases

Lerma Rojo, Yaqui 54, Gabo 55, Gabo 56, and Toluca 53 continue to be resistant to all of the races of stem rust prevalent in North America. Even though Yaktana 54 is susceptible to the new race 24, which appeared two years ago, sporadic plantings of this variety were observed to be perfectly clean. Notwithstanding, the level of production of this variety and of other wheats with the same type of resistance must be kept to a minimum until race 24 ceases to be potentially dangerous. Late plantings of Gabo 48 showed slight infections, probably due to race 15B which persists in trace amounts.

The heavy infection with leaf rust observed during the 1958–1959 cycle was greatly reduced this season. A small area represented by late plantings showed the severest infections. Even though commercial varieties are susceptible to this disease, there is evidence that damage in general is unimportant, although this may vary with climatic conditions. For instance, last year, when yields were generally very low and Lerma Rojo suffered a serious infection of leaf rust, the resistant variety Kentana 54 likewise showed low yields.

THE BAJIO

Climatic Conditions

Climatic conditions in the Bajío were generally very favorable for wheat, and plantings were performed in a normal manner except in some isolated regions where heavy rains during the latter part of December resulted in poor emergence. On the whole, temperatures favored the development of the plants, but in January and February severe frosts occurred which varied from 0° to −7°C. These low temperatures did not affect the crop in the greater part of the Bajío; in the Ciénaga de Chapala, however, where farmers usually plant early with Barrigón, Bajío, and Lerma Rojo, frost damage on some farms ranged from 50% to 100%. During the first part of April, there were noticeable drops in temperature, in some places down to −5°C. Suffering most from these late frosts were plantings in Querétaro, Durango, Zacatecas, Aguascalientes, and the northern part of Guanajuato. It is estimated that in these areas more than 8,000 hectares were completely destroyed and approximately 10,000 hectares more suffered yield reductions of from 15% to 20%.

Cultural Methods

Practically all farmers in the central part of the Bajío use some fertilizer on their wheat, but there is still a considerable percentage who do not fertilize adequately. Yields in this region may easily average over 2,500 kg./ha. once all farmers put rational fertilizer practices into effect. Land preparation, planting, and water management practices continue to improve each cycle.

Varietal Performance

Lerma Rojo represents more than 90% of the area cultivated to wheat in the Bajío. This situation is detrimental to the milling and baking industry for the reasons already mentioned, and also represents a potential danger to national agriculture, since the appearance of a new physiologic race of stem rust virulent to Lerma Rojo would cause widespread damage. Lerma Rojo is moderately susceptible to the leaf-rust races prevalent in the Bajío, but continues to be very resistant to stem and yellow stripe rusts. Although it produces rank vegetative growth in this region, it rarely creates a problem because of lodging. Three new lines are now being multiplied which will compete with Lerma Rojo as regards yields.

Chapingo 53 is tending to disappear in the Bajío, although it is still in great demand by the milling and baking industry which requires this type of wheat. It is possible that this variety occupied only about 1,000 hectares in the central Bajío during the past cycle. In the region of Aguascalientes, however, it represented more than 50% of the total area planted to wheat.

During the past three years, Gabo 56 has been successfully cultivated in the Bajío, but a small sector of the milling and baking industry, doubtless unaware of the excellent quality of this variety, has down-graded it because it is a white grain wheat. The gluten strength of Gabo 56 is similar to that of Yaqui 50, and much superior to that of Lerma Rojo.

The varieties Yaktana 54, Kentana 53, Anáhuac, and Barrigón, all of which yield less than Lerma Rojo, were planted only in limited zones.

Pests

Losses caused by field rats were reduced to less than 10% of the entire crop as a result of wider and more complete chemical control. There is still need, however, for an intensive control campaign, not only on the land under cultivation but also in the adjacent fields which are covered by wild plants. The rat problem is considerably more serious in this region than in the Northwest, since the corn stalks which the majority of Bajío farmers leave lying in the field serve as an ideal breeding place for rats.

Although the damage caused by aphids during this cycle has not been generalized, in some fields the losses represented from 10% to 15% of the crop. Aphids become a problem of economic importance two years out of every five, unless controlled chemically. The Bajío now has the services of various private companies which, by means of aerial spraying, have managed to control the pest within a few hours. The problem remains of getting the farmer to apply insecticides before yields are reduced in those years when ecological conditions favor the development of epidemic infestations.

Diseases

Climatic conditions during this cycle were unfavorable for the development of either stem rust, yellow stripe rust, or leaf rust.

HIGH VALLEYS OF THE CENTRAL AND NORTHERN MESAS

Climatic Conditions

Climatic conditions in these regions were, in general, favorable for obtaining good yields. In the "temporal" (dry farming) section of the Sierra de Arteaga in the State of Nuevo León and in local areas near Texcoco, México, lack of sufficient water resulted in poor plant development. In the remaining portion of the regions, however, yields were superior to those obtained in previous cycles.

In the States of Puebla and Tlaxcala, environmental conditions were very favorable for the development of heavy epidemics of stem and leaf rust during the summer of 1959.

Cultural Practices

Although a large percentage of the farmers still use rudimentary methods, the use of fertilizer is spreading rapidly, and it is possible that the best harvest in the history of the States of Puebla and Tlaxcala occurred during the past summer cycle.

Varietal Performance

Lerma Rojo continues to occupy the greatest percentage of the area devoted to wheat. It is still the most resistant to the stem-rust races prevalent in Mexico, but damage due to attacks of leaf rust is rapidly growing in significance.

Yaktana 54, the second most important variety, is completely susceptible to race 24 of stem rust, which first appeared in Mexico during the summer of 1958. The areas planted to this variety in the States of Puebla and Tlaxcala suffered serious reductions in yield due to race 24, and this cycle may be the last one in which Yaktana 54 will be planted extensively.

Pests and Diseases

No damage due to rats or aphids was reported for any part of this region.

As reported above, Yaktana 54 was seriously damaged by stem-rust race 24 in the States of Puebla and Tlaxcala. In the northern part of Coahuila, the variety Lagunero 58 was planted extensively for the first time and suffered severe attacks of leaf rust, although these had little effect on yield.

The need for producing an improved variety for the northern part of Coahuila is urgent. This variety must be much later than the varieties planted at present, and should have adequate resistance to leaf rust and complete resistance to stem rust. Some re-selected lines from the cross II–53–388 from Minnesota, which are now being multiplied, appear to possess the required characteristics. Eventually the material from the Chilean Agricultural Program will be ideal for this region.

EXPERIMENTATION

COMPOSITE OR MULTILINEAL VARIETIES

The experimental aspect related to the formation of composite varieties has entered a more interesting phase now that the first varieties have reached the first stage of multiplication.

In order to observe the possible variation in performance, varieties composed of first, second, and third generations were multiplied simultaneously after the mixing was effected. From a practical point of view no appreciable differences in the morphological and agronomic aspects were observed among the three multiplication lots, nor were any significant differences in yield noted.

Experimental data also show clear evidence of little or no effect of population shifts of the mixtures on yields. During the 1959–1960 cycle, the first, second, and third generations of three different composites of Yaqui 50 were included in comparative yield trials, the check in each case being the recurrent parent, Yaqui 50. Although the statistical analyses have not been completed, it can be estimated with a good margin of certainty that no difference exists among the yields of the three generations of the composite, the recurring variety, and the average individual yields of the lines making up each composite. These results are of the greatest importance, since if no significant changes occur in the productivity of a composite after several generations of consecutive multiplication, it will not be necessary to form new composited seed lots every year and utilization of composite varieties on a commercial scale will thus be greatly simplified. The formation of a new composite depends on the appearance of new rust races and the need to maintain an efficient control of the formation of each composite variety during the first stages of multiplication.

Intensive work is also in progress on the improvement of agronomic characteristics of the recurrent varieties that serve as a basis for the formation of the composites. Various lines derived from crosses between Yaqui 50 and Japanese dwarf varieties have now been obtained. These lines are a result of five or more backcrosses with Yaqui 50 in which dwarfness and the Yaqui 50 types have been combined. From these the best line will be selected for crossing with promising lines having diverse resistance genes. In this manner it will be possible to obtain within three or five years a dwarf composite variety much superior in yield and agronomic performance to the varieties of normal height which are now available.

In addition to the study of composite varieties derived from Yaqui 50, lines and different mechanical composites are being evaluated in order to form composites derived from other varieties like Gabo 48, Lerma 50, and Kentana 48. A composite derived from Lerma Rojo is now in formation in which special emphasis has been given to the incorporation of resistant genes to *Puccinia triticina* (leaf rust). The first lines will be tried out for yield during the next two cycles.

PERFORMANCE OF DWARF VARIETIES

In previous reports mention has been made of the results obtained in the formation of dwarf varieties. These varieties have been selected from crosses made in Mexico between Mexican wheats and those derived from the Japanese variety Norin 10, which was obtained from the cross Turkey × Fultz made in 1924 at the National Experiment Station in Tobuca, Japan. Various lines of Norin 10 were introduced into the United States, where they were used extensively at the experiment station in Pullman, Washington. From there, various lines of Norin 10 × Baart and Norin 10 × Brevor were introduced into Mexico. The OEE initiated in 1949 an intensive program designed to produce short-strawed wheat having a yield equal to or higher than that of the commercial varieties then in cultivation. Fortunately, the great majority of the selections made in diverse crosses have resulted in yields much above those of commercial varieties.

From segregating material it has been possible to select some 10,000 lines possessing agronomic characteristics greatly superior to those of the commercial varieties. The best new selections also have better characteristics than the first dwarf lines selected by the program.

Experimental results obtained in the 1958–1959 cycle in the Bajío indicate as outstanding the following lines: Yaktana 54 × Norin 10-Baart 26, II–7064–10y–5h–4R–1M; Yaktana 54 × Norin 10-Baart 21, II–7037–3c–5h–1R–5M; [(Norin 10-Baart 17 × Yaqui 53) Yaqui 50] × Kentana 54, II–7756–4R–3M–1R; (Frontana × Kenya 58-Newthatch) × Norin 10-Baart 1, II–7078–1y–2h–7R–4M. Various sister lines exist which also are outstanding as regards yield. The majority of them have an acceptable reaction to the wheat diseases most common in Mexico. With the inclusion of these wheats, it may become possible to diminish considerably the problem of lodging in the Bajío, and thus permit the use of heavier rates of fertilizers.

From the dwarf lines included in yield trials in the summer of 1959, the most outstanding as regards yield and reaction to diseases were: (Frontana × Kenya 58-Newthatch) × Norin 10-Baart 1, II–7078–1R–6M–1R-1M; Kentana 54A × Norin 10-Baart 21, II–7028–10y–1h–1R–2M; and Selección No. 5 × Norin 10-Baart 24, II–7011–1c–1h–1R–5M. Of these, the first and last are now in experimental commercial plantings in order to study the problems that may be involved in the practical utilization of a new type of plant, as regards both cultural practices and adaptability to mechanized harvesting.

All dwarf varieties were acceptably resistant to brown necrosis, and except for line II–7078–1R–6M–1R–1M, were also resistant to stem rust. Resistance to yellow stripe rust and leaf rust was generally very acceptable.

PERFORMANCE OF EXPERIMENTAL VARIETIES

Experimental varieties which outyielded Lerma Rojo in the Northwest were: two dwarf wheats, Yaktana 54 × Norin 10-Baart 26, II–7064–1y–1h–1R–2M, and (Frontana × Kenya 58-Newthatch) × Norin 10-Baart 1, II–7078–1R–6M–1R–1M; two varieties derived from the cross P–4160, Nainari and Cajeme 60; and the line Lee-Frontana × Kentana 52A^2, II–3962–2h–2y–3c–1y. These five varieties are now in the first phase of multiplication, and it is likely that lots of 2,000 hectares or more will be planted in the 1960–1961 cycle.

The adaptation of modified cultural methods will be studied conscientiously in order to improve yields of some of the new varieties which can produce well on the strength of their intrinsic genetic characteristics alone. Modifications will be made as regards rate of seeding, planting methods, fertilization, and irrigation. Experimental evidence has indicated that with dwarf wheats, average yields of above 4 ton/ha. can be obtained.

DURUM WHEAT VARIETIES

The experimental variety derived from the cross Caravaca × (LD357-Capelli), which was first multiplied in the 1958–1959 cycle, has been named Tehuacán 60. This variety seems to have good adaptability to both summer and winter plantings, and may meet the demand for adequate flours for the manufacture of spaghetti, noodles, etc.

Particular emphasis is being given to obtaining durum dwarf wheats of good quality. The Norin–10 double dwarf genes have been successfully transferred to durum wheats. The best lines are already in third or fourth segregating generations, and by means of a backcross the program is endeavoring to fix the quality of the new dwarf lines of durum wheat.

Barley

Barley breeding in Mexico has become very important within the past few years, owing no doubt to the great demand for this grain on the part of the malting industry and of the manufacturers of cattle, hog, and poultry feeds.

It is calculated that an area of some 250,000 hectares is now devoted to barley culture in Mexico. The crop extends from altitudes of 2,000 meters or more above sea level, in the high valleys of the Mesa Central, to locations of scant altitude, such as the northwestern coast. Cultivation is effected during two well-defined seasons: in summer, during rainfall, in the States of Hidalgo, México, Tlaxcala, and Puebla; and in winter, under irrigation, in the Bajío and on the northwestern coast. At present, summer plantings are the more important and constitute over 90% of the total area devoted to barley. Irrigated plantings during winter are becoming increasingly important, however, not only because of the large demand for this grain but also because barley represents another crop with which to diversify winter plantings.

VARIETAL PERFORMANCE

The largest percentage of the 1959 summer crop consisted of criollo varieties of barley. The improved variety Toluca 1 was planted in an area of about 5,000 hectares, found mainly in the States of México, Hidalgo, and Tlaxcala. Its yields were good as a whole, with a general average of about 1,500 kg./ha. The Canadian varieties Vantage and Winnipeg were grown on a commercial basis for the first time during this season. Both are of relatively good quality from the malters' point of view. As they appear to be better adapted for winter plantings under irrigation, they will probably tend to replace Toluca 1, because of their greater ability to resist breaking of the necks under the dry conditions of the winter season.

During the 1959–1960 winter cycle, the area planted to barley exceeded 5,000 hectares for the first time. The predominant variety was Toluca 1. Results in general were very satisfactory. Yields varied from 1,500 to 4,000 kg./ha. and averaged approximately 1,800 kg./ha. for the Bajío region. Toluca 1 has a relatively weak neck, however, and some farmers reported losses due to this defect. Consequently, in spite of its high yielding ability and its great acceptability to the malting industry, this variety will have a rather limited distribution and may be recommended only to those farmers who harvest at the appropriate time.

Second in importance during the winter plantings was the variety Vantage. In the Northwest, it occupied about 1,000 hectares. Plantings made in mid-December were the best. Late plantings were so severely attacked by leaf spot (*Helminthosporium teres*) that some farmers were obliged to plow up their plantings. There is great need for a barley variety of good quality, resistant to diseases (especially leaf spot) and possessing a strong neck, that will thrive as an irrigated crop in the Northwest. In the Bajío, Vantage performed well, and it is quite possible that within two or three years it will take the place of Toluca 1. At present, it is the highest-yielding commercial variety.

Good tonnage of seed was obtained from the winter plantings in the Bajío, and this is serving to supply seed demand for summer plantings in 1960.

For the time being, with winter plantings of Vantage in the Northwest and the Bajío and of Toluca 1 in the Bajío, and with summer plantings, principally of Toluca 1, in the high valleys, production will easily be sufficient to satisfy the demands of the malting industry.

Improved bean varieties for the Gulf Coast tropics.

Beans and Soybeans

The bean and soybean program continued experimentation directed toward the production of sufficient vegetable protein to satisfy the national needs of Mexico. Favorable growing conditions during the 1959–1960 cycle led to good harvests, and imports of beans were greatly reduced in comparison with the previous cycle. Utilization of the natural hybrid "intermediates" between *Phaseolus vulgaris* (the common bean) and *P. coccineus* (Scarlet Runner) has begun in the breeding program. A number of very promising lines of hybrid derivation (Cuban selections × Bayomex) will be placed in their first yield trials in the summer of 1960.

In the area of more basic research, work has been started in cooperation with the Biochemical Laboratory of the National Nutrition Institute to determine the amino-acid food value of beans, the variation that exists, and the mode of inheritance of these factors.

Basic research on the nutritional requirements of *Chaetoseptoria wellmanii* has been in progress for some months. This information will aid greatly in the screening of candidate variety-lines for resistance to attack from this fungus. Studies are being continued of the bean bacterial blight organisms, to determine both the variability of bacterial strains in Mexico and the susceptibility-resistance reactions of bean genotypes. Over 4 tons of certified basic seed of improved varieties has been turned over to the appropriate government agency for increase and distribution.

Bean Breeding and Improvement

EL HORNO

The history of any new bean variety includes several years of observation and yield trial. Because a variety must be "pure," i.e., uniform as to growth habit, seed color, maturity date, disease reaction, etc., the off-types must be rogued to remove them from the population. With beans, genetic segregation of visual characteristics (flower color, seed color and shape, disease reaction, etc.) continues for four to five generations after the cross, and candidate varieties must therefore be in observation and reselection throughout this period. Beginning in the F_4 generation, the new lines are placed in yield trial for comparison with lines of known yield potential that are also uniform.

After seven years of improvement work on beans in Mexico, three generations of improved varieties have been produced. The first generation was composed of the pure-line single-plant selections made in 1953 and released in 1954, and included the varieties Canario 101, Bayo 158, 160, and 161, Negro 150 and 151, and Pinto 162. The second generation of improved varieties was obtained by crossing. The first of the varieties of hybrid origin were released in 1959; among these were Canocel, Bayomex, and Negro Mescentral. The third generation of improved varieties is represented by nine lines, superior in yield trials in the last two years and going into both yield trials and first seed increase in 1960. In 1960, small samples of seed of these lines will be sent out to extension agents, cooperating farmers, etc., for actual field testing under farmers' conditions. The majority of these nine lines will be discarded for one reason or another, but two or three of them will probably be released as new varieties in 1962.

The fourth generation of improved varieties is represented by 80 lines selected in the F_2 in the field last year. These crosses are based on the improved Bayomex variety crossed with superior single-plant selections from the Cuban imports first observed in 1958. In 1960, 100 outstanding plants will be selected to be placed in further observation and selection in 1961.

Radiation Study

From the great quantity of thermal-neutron and X-ray irradiated material originally observed for lethal effects in 1957, 18 lines have been selected that appear to be clearly superior to their "parent," Canario 101. These lines are the result of germinal mutation induced by high-energy radiation, and will go into first yield trial in 1960.

Interspecific Natural Hybrids

In the study on interspecific natural hybrids between *Phaseolus vulgaris* and *P. coccineus*, particular emphasis was placed on observation of insect and disease resistance, cross-fertility of the intermediates, and the continuance of the statistical study of the morphology of the intermediates. The results to date statistically confirm the hypothesis of the existence of an intermediate type between the two species.

COTAXTLA

Nearly 400 lines from the black-seeded, Cuba-Bayomex (F_2) crosses, new collections, and introductions were planted in observation. All of these were high-pressure inoculated with the Severe Bean Mosaic Virus 17 days after planting. Notes were taken regularly on susceptibility to the virus, vigor, adaptation, rust resistance, and apparent yield. Of the approximately 24,000 plants, 609 (3%) were selected for replanting in the spring of 1960. Seven observation and yield trials of advanced generation lines were planted at Cotaxtla, Villa Cardel, Zempoala, Martínez de la Torre, and San Rafael, Veracruz, in the spring of 1960. These plots were the location of several local field days for farmers interested in beans.

CIANO

Although common beans are not, and probably never will be, a primary crop in the Northwest, some farmers in the area have done very well with this crop. Yields of the variety Canario 101 passed 3 ton/ha. last year. For this reason, a small-scale bean project will be continued at this station. The work will be limited to the testing of lines of hybrid origin from other areas and to maintenance of pure-seed stocks of improved varieties.

SPECIAL STUDIES

NUTRITIVE VALUE OF BEANS

To the present time the major emphasis in bean improvement has been on obtaining higher yields through new varieties with greater yield potential and disease resistance and through cultural practices that permit improved varieties to realize their yield potential. The cultural techniques and improved varieties now exist, and if widely employed, will produce more than sufficient beans for the national need. Of more fundamental importance is the nutritional significance of beans in the Mexican diet. The daily consumption of beans represents the major source of protein material in the Mexican diet. It is therefore essential that the quality of bean protein (amino-acid content) be studied.

In cooperation with the Biochemical Laboratory of the National Nutrition Institute, a series of studies has been initiated to determine the quantity and quality of amino acids in beans. This program involves the analysis of bean lines for amino-acid fractions and a related study of the relationships between bean types and inheritance of factors controlling bean protein. The Biochemical Laboratory now has the equipment (Beckman-Spinco chromatographic amino-acid analyzer) to make such analyses rapidly and accurately. Preliminary studies have enabled the determination of normal standard deviations of amino-acid analysis. From the first set of materials examined it is also apparent that different bean lines vary significantly in amino-acid content. As more data are accumulated, these will be utilized in the breeding program, as another heritable characteristic to influence the selection of candidate lines.

SEED TREATMENT

Experiments on chemical seed treatment and its effect on stand and yield were continued. Of 46 different treatments, 15 were superior to untreated seed in both stand and yield. Among the better materials were Zinc 2,4,5-trichlorophenate, Streptomycin nitrate and sulfate, Ethyl mercury phosphate, Pentachloronitrobenzene, and various metallic salts of bis-dithiocarbamic acid. These results have clearly demonstrated the advisability of seed treatment. The best five compounds gave an 8–15% increase in yield over untreated seed.

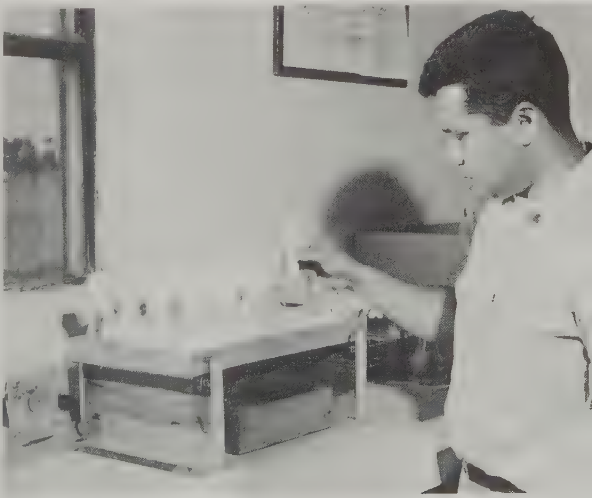
GROWTH REGULATORS

Experiments were also continued on the influence of growth regulators on bean yield. The materials used were potassium gibberellate and 2,4-dichlorophenoxyacetic acid. Although results were not as spectacular as in the previous year, they again showed that when minute quantities of potassium gibberellate (1 ppm) are applied at flowering time, the treated plants develop more seed than the untreated check.

BEAN DISEASES

Circular Leaf Spot

The circular leaf spot disease of beans caused by *Chaetoseptoria wellmanii* continues to be of importance. A well defined host-genotype - resistance - susceptibility relationship has been determined. Work in the laboratory with this fungus has made it possible to develop pure cultures of the organism and to induce sporulation in culture. Because of the observed fastidiousness of the cultural



Liquid cultures of the fungus *Chaetoseptoria wellmanii*, used in fungus nutrition studies, on home-made culture shaker.

nutrient requirements of the fungus, a series of experiments on its carbon and nitrogen requirements has been carried out. On the basis of tests with a large number of organic and inorganic nitrogen sources and with a number of carbohydrates, it has been determined that: (1) although the fungus prefers organic N, it has the ability to utilize inorganic N as nitrates (NO_3); (2) the preferred carbon source is d-maltose; (3) the fungus can utilize most d-hexoses as a C source, but can utilize only slightly or not at all l-hexoses and pentoses. At present experimentation is under way to determine the C/N ratio most conducive to growth.

The cultural experiments are conducted in 125-ml. flasks carried on an OEE-designed, low cost, culture shaker. The fungus is liquid-cultured in a basic inorganic buffered solution, to which the test materials are added. Mass increase after 12 days in culture, as determined by weighing air-dry mycelium in tared aluminum microcups, is used as the growth measurement.

Future work is planned on the vitamin and pH requirements of the fungus. After determination of the cardinal nutritional requirements, an attempt will be made to correlate these results with host-genotype-resistance-susceptibility reactions.

Bacterial Blights

The bean bacterial blights caused by *Xanthomonas phaseoli* and *Pseudomonas phaseolicola* continue to be a problem in the Central Mesa area and in the Bajío. In cooperation with the Graduate School of the National School of Agriculture, a young Mexican scientist is studying the geographic distribution of the pathogen, the races or strains of the bacteria present in Mexico, and the inheritance of susceptibility and resistance to attack in bean lines. Two members of the bean section are acting as graduate research advisors to this program and greenhouse, laboratory, and field facilities have been made available. It is expected that the final results of this project will indicate the location of resistant genes to this disease and the mode of inheritance. It is hoped that this type of cooperative research between the OEE and the Graduate School can be increased in the future.

Extremely early Minnesota-type soybeans, grown in a fall planting in the tropics.

SOYBEANS

The work at CIANO during the past year has been limited almost exclusively to soybeans. In yield trials, the variety Lee has continued to be the best from a commercial standpoint. In spite of its high yield, however, it has the unfortunate characteristic of late maturity, requiring 160–180 days to mature under Sonora conditions.

From the start of the soybean project, it was realized that eventually, as soybean culture became a commercial enterprise, a breeding and selection program would have to be initiated. Through the cooperation of the U. S. Department of Agriculture, the Rust Prevention Association, and several large seed producers in the United States, 410 soybean lines representing maturity groups O, I, II, VI, VII, and VIII were sent to us for trial. The materials from groups O, I, and II were very early (35–60 days) in their maturity, but very low-yielding. These will be used as "early" parents in crosses with Lee, Hill, Dorman, etc., to select in the F_2, high-yielding lines of early maturity. The group VIII material was comparatively better in yield but extremely late in maturity (200 days). From groups VI and VII, 332 mass and single-plant selections were made of types that appeared high-yielding and of a maturity period of 110–120 days. These lines also will be crossed with Lee, Dorman, Hill, etc., for the selection of a high-yielding, short-maturity type in the F_2 and subsequent generations.

Seed increase plots of Lee, Dorman, and P.I. 97066 B.S. were planted and the harvested seed sold to interested farmers. Because the demand for seed in 1959 was much greater than could be supplied from CIANO, the commercial companies in the area imported over 100 tons of seed from Arizona, principally of the variety Lee. About 3,000 hectares of soya were in commercial planting in 1959, and it is estimated that the 1960 planting will be in excess of 25,000 hectares. This indicates both an interest in and a commercial future for soybeans in the area, and a large-scale breeding program is therefore justified.

Field grading squashes.

Horticulture

Breeding work on peppers, squash, and tomatoes assumed greater importance during the past season. Attention was also given to crops not previously studied, such as garlic, and at one station the collection and improvement of native vegetables received emphasis. A new garden pea variety for the Toluca Valley was named Santa Elena 626, and basic seed was produced in Sonora. Trials were continued on a modified scale to test new improved varieties developed in other parts of the world. Home garden demonstrations and providing recommendations on vegetable production were important activities at the field days.

Results By Stations

EL HORNO

Pepper Improvement

Studies in method of controlled pollination, selection of better types within varieties, and screening of lines apparently resistant to fungus diseases are important aspects of the pepper improvement work done during the past year.

In a comparison of several materials for caging whole plants, nylon screening gave an average yield of 36 fruits per plant, which was the highest. Wire screen mesh and cheese cloth, when used to cover cages, resulted in average yields of 27 fruits per pepper plant. The least efficient materials were organdy and muslin. In studies made to compare the effectiveness of different materials for covering single blossoms and assuring selfing, 52% normal selfing was obtained by thin copy paper, glassine bags, or gelatine capsules, as against 7% for cellophane bags or envelopes. In cross-pollination tests, gelatine capsules and thin copy paper were more effective than glassine or cellophane bags. The best stage for effecting cross-pollination is when buds are about to open. No interaction was found between the various stages of bud formation and the efficiency of the different protective materials studied.

In 1959, specialists of the plant pathology section took part in the horticulture section's pepper breeding project and inoculated several selections with *Phytophthora capsici* races, which are the causal agents of root rot and wilting. Five selections of commercial types from the Pasilla and Poblano varieties (*Capsicum annuum*) of Mexico, and two introductions from La Molina, Peru (*C. pendulum*) showed promising resistance. This cooperative work will be carried on during 1960 with the hope of increasing seed of the better lines shortly to meet the urgent need for resistant varieties.

Other Vegetables

Over 500 collections of local types of squash have now been made, and a large proportion of them have shown a high degree of variability. In plantings made in 1959, consisting of superior selfed lines selected from the previous year and of certain new accessions, 33 lines were again selected for good horticultural characteristics. Seven lines have been chosen this season on the basis of field performance and quality. There has been little loss of vigor in the inbred lines.

Progress was made in producing a uniform line of squash which bears naked seed. The fact that cotyledons are covered only with a thin membrane suggests an easy method for producing seed for roasting without the expense of hand-shelling or for oil extraction. The line, which is derived from a segregating seed introduction in 1957, produced in 1959 only seed of the desired type. A chemical analysis of this seed showed a protein content of 36.51 mg. and 44.05 mg. oil content.

In garden pea trials, the best quality was produced by Pride, Loyalty, No. 626, Burpeeana Early Dwarf, Du Cheming, and Annonay, which also showed a medium degree of resistance to powdery mildew. The local collection XVI–64, an introduction from the United States P.I. 180326 P.S., and No. 626 showed promising mildew resistance.

In snapbean trials, Tendergreen, Contender, and Tenderbest were outstanding in uniformity and quality.

CIANO

Comparison of Melon Varieties

A comparison was made of the adaptation of 12 melon varieties planted January 10, 1959. Data were taken on horticultural characteristics and incidence of insects and diseases. The Edisto variety was rated the best over-all variety, although MR–450–D, SR–91, and Neuman Special were also good. The Honeyball Oro Blanco variety was the best of the small-fruited group. Table 1 presents some of the data from this trial.

Watermelon Variety Trials

Watermelon trials started January 10, 1959, indicated that 122 days were required from planting to first harvest of all six varieties tried. The best over-all results were obtained with the W. Res. Peacock, Improved Peacock, and Charleston Gray varieties, which yielded 18, 17, and 15 ton/ha., respectively, and produced the largest watermelons. The Charleston Gray variety showed the greatest degree of resistance to anthracnose, while the Peacock strains were more adversely affected by this disease.

Single-strip tests with several fungicides showed some favorable reaction from Parzate and Bayer 4445 (experimental material) and to a certain degree with Fungisol M, as judged on the basis of disease control and yield response.

A second planting was made February 10 with the same six varieties sown in January plus 20 new ones. The harvest period started May 27 and continued until July 11. High temperatures during the latter part of the growing season were apparently detrimental, although the plants developed well. The information obtained suggests that better varieties than the commonly grown Peacock strains may be available. For instance, Charleston Gray, Black Diamond, Florida Giant, and Stone Mountain yielded 15, 16, 17, and 22 ton/ha., respectively, as against only 12 ton/ha. for Peacock. In general, plantings in early January gave better results than those made in February.

TABLE 1.

Yield and main horticultural characteristics of 12 melon varieties. CIANO, January 10, 1959, planting.

	Variety[a]	Yield (ton/ha.)	Days to maturity	Sugar content (%)	Av. weight per fruit (kg.)	General appraisal
1	Edisto	17.8	133	9.8	1.12	Excellent
2	Honeyball "Oro Blanco"	17.2	118	9.8	0.59	Excellent
3	SR-91	15.6	126	8.6	1.04	Very Good
4	Dessert Sun	15.4	119	8.9	0.91	Good
5	Neuman Special	15.1	126	9.8	0.91	Very Good
6	SR-1463	15.1	123	7.6	1.02	Good
7	4-50	13.3	118	10.0	0.79	Good
8	MR-450-D	13.1	126	9.9	0.92	Very Good
9	Honeydew Green Flesh	12.5	130	11.8	1.30	Good
10	No. 45	12.3	119	10.2	0.78	Good
11	Crenshaw	11.1	139	9.9	2.30	Poor
12	Casaba Golden Beauty	9.8	143	7.0	1.59	Poor

[a] Source: Nos. 1, 4, 6, and 8 from Dessert Seed Co.; Nos. 2, 3, 5, 7, 9, 10, 11, and 12 from Neuman Seed Co.

Onion Variety Trials

Yellow-fleshed onions outyielded the standard Cojumatlán (local) and Crystal Wax varieties of white color in a replicated test carried out from March to May. Keystone Yellow Sweet Spanish No. 6, with a yield of 21.14 ton/ha., was the most productive variety, but thick stems that do not dry down in time make it less desirable than Texas Grano 502, which yielded 20.24 ton/ha. There was no significant difference in yield between these two. Granex, also yellow, had a yield of 17.89 ton/ha. The two white-fleshed varieties gave yields significantly lower than any of the yellow ones at odds of 99 to 1.

In other row plantings, the short-day hybrids Asgrow W–10 and W–1 gave indications of excellent adaptation to the Northwest.

Peas

In the two previous seasons several planting methods were compared for pea production in large single blocks. During the 1959–1960 season, a replicated test was made with the Pride variety, which is intermediate in maturity, and single plots were set out with the Alaska and Shasta varieties, which are early- and late-maturing, respectively.

The five methods compared did not show significant differences in total yield of dry seed, although there was an apparent tendency for higher yields from single rows on beds at 75-cm. spacing and from double rows on beds at 92-cm. spacing. The single rows at 17.5 cm. drilled like grain without beds, proved impractical although high in yields. Single rows on beds at 92 cm. have given very low yields.

The test this season with Shasta also showed that the best yields in fresh pods and dry seed could be obtained by planting single rows on beds at 75-cm. spacing. With Alaska there was a marked tendency toward higher yields from double rows on beds at 92 cm. and from single rows at 17.5 cm. drilled on level ground.

Data taken on a total of 61 lines and varieties on three dates regarding possible resistance to powdery mildew, showed that three introductions from South America

(XVI–112, XVI–113, XVI–117) and the Mexican line XVI–64 may have some value in the breeding program.

Tomato Yield Tests, Sinaloa

During the 1957–1958 and 1958–1959 winter seasons, replicated experiments were carried out in the Culiacán, Sinaloa, area to determine the yield potential of new and standard tomato varieties as well as of promising experimental lines. The weight of fruit harvested from the first four and five pickings, which have the greatest market value, was analyzed statistically. The results indicate that in 1957–1958, STEP 268, 278, and 260 gave the best yields from the first four pickings (20.6, 20.0, and 19.7 ton/ha., respectively), and were significantly superior to Kokomo, Homestead 2, and Rutgers. Cotaxtla I gave a good yield, but the plant does not develop in the same manner here as it does on the Gulf Coast.

During 1958–1959, very high yields of 40 ton/ha. were obtained in the first five pickings of Manalucie, which has been one of the main staking tomatoes of the region, and of STEP 274, now named Indian River. Among the new lines, STEP 282 and 290 were selected for increase and further evaluation.

SANTA ELENA

Native Vegetables

The studies on native vegetables continued to draw interest from farmers and agricultural leaders of the Toluca Valley during the past season. Thirty collections of fava beans (*Vicia faba* L.) made in five States were planted, out of which 148 selections were made; this total includes the best ones from the previous season. From seven collections of huauzontle (*Chenopodium mittaliae* Saff.), a leafy vegetable, different types were selected for maturity dates and size of plant.

Vegetable Improvement

Progress was made in breeding and selection of superior forms of vegetables which are well adapted to the area. Using materials derived from crosses started in 1957 between the Gold Crest sweet corn variety and the local Cacahuazintle corn used as fresh corn, a breeding plan was set up in cooperation with the corn section to carry forward the production of a locally adapted corn of high quality. From 132 selections from true seed of the Green Globe artichoke variety, 14 were marked as definitely superior and will be compared in a replicated yield test in 1960. The asparagus variety UC 309 outyielded three others for the third consecutive year, and a new isolation block was set out with selected plants for future seed production. Five different selections were made out of a number of plants of the Victoria rhubarb variety, which showed good petiole development and productivity.

Recommended Varieties

The following varieties were considered the best in variety trials and comparative yield tests during the past season:

Cauliflower: Snowball E. *Onions:* E. A. Crystal 281, White Granex, Asgrow W–1, and Cojumatlán, all white. *Snapbeans:* Tenderlong 15, Red Asgrow Valentine, and Taylor Horticultural, with Tenderlong and Contender rating the highest in quality. *Cabbage:* Langedijker Early Autumn, although in a replicated yield test Bonanza was the best in quality and Glory of Enkhuizen the highest yielder. *Lettuce:* Merit and Great Lakes R–200, although Merit was severely attacked by disease.

These varieties were also grown at the station in demonstration home gardens.

New Garden Pea Variety

Over the past seasons there has been increasing need for an early or midseason pea that would have better quality than the Alaska variety and yet have some resistance to seed rot. Studies on factors governing seed rot in the soil and intensive trials have resulted in the choice of line No. 626 as a midseason pea with desirable characteristics for the Toluca Valley. No. 626 was received several years ago from Ferry-Morse Seed Co. as a breeding line in which they had no further interest. It is being named Santa Elena 626 for the station where it was selected. During the 1959–1960 season, 300 kg. of basic seed was produced at CIANO, and samples were given to farmers in the Toluca Valley for spring planting early in 1960. The performance of Santa Elena 626 in a 1959 yield test is indicated in Table 2.

TABLE 2.

Yield and characteristics of eight pea varieties. Santa Elena, 1959.

Variety	Av. pod length (cm.)	Days to maturity	Suscept. of pods to mildews[a]	Yield (ton/ha.)
Santa Elena 626	7.8	90	3	3.5
Shasta	7.8	90	4	3.1
Rainier	7.6	98	2	2.7
Pride	7.3	90	4	2.7
Alaska	6.5	83	5	2.4
Thomas Laxton	7.5	83	4	2.2
Miracle	9.0	98	3	1.5
Alderman	8.5	105	2	1.2
L.S.D.—5% level				1.5

[a] Scale of 1=resistant, 5=susceptible.

LA CAL GRANDE

Garlic Varieties

Garlic production is one of the main horticultural activities in the Bajío area, but the crop had not been the object of a formal study until recently. Over an 18-month period in 1958 and 1959, a preliminary survey was made of the characteristics of the important garlic varieties and the cultural practices followed in the Cortazar area of Guanajuato. This State produced 71% of all garlic grown in Mexico in 1957. It is estimated that at least half the crop is exported. In 1958 the United States imported 86% and a large part of the remainder went to several countries in the Caribbean.

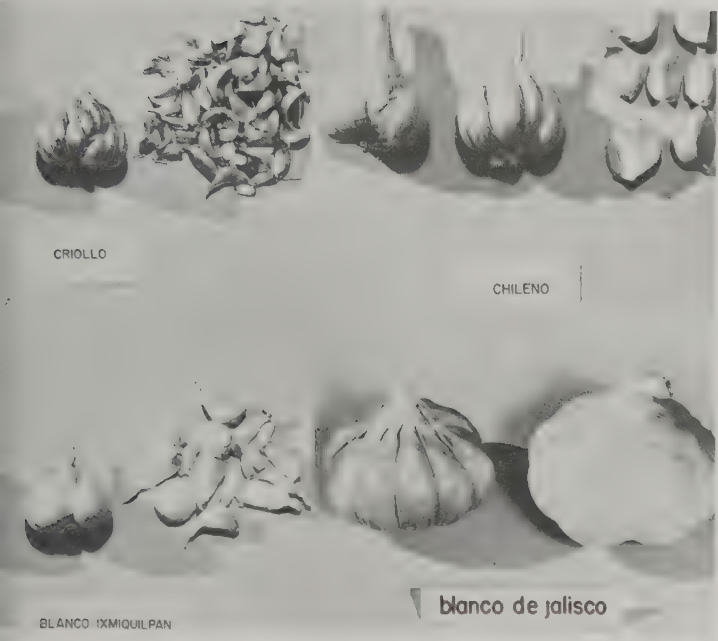
The most popular variety grown in Mexico is the Chileno, distinguished by white bulbs tinged with purple which contain a relatively small number of medium- to large-sized cloves. The criollo variety, believed by many to be a form derived from the Chileno, is identified by a purplish bulb containing many small to medium cloves. It does not generally yield as well as the Chileno. These two varieties account for the larger portion of the early garlic, although the Japonés, which produces a medium-small white bulb, is the earliest variety and is grown to a certain extent. Days to maturity for these three varieties average 183, 165, and 135, respectively. Blanco de Jalisco and Blanco de Ixmiquilpan, which have white bulbs and on the average mature in 210 and 243 days, are considered the late varieties and are grown primarily for the local market. Yielding ability of these five varieties is shown in the data from two replicated experiments presented in Table 3.

Preliminary observations of current practices suggested that garlic production might be improved through better selection of planting stock. Important differences in yield were found in two replicated experiments where large-sized cloves of both the Chileno and criollo varieties produced greater yields than medium or small cloves of the same varieties. Differences were significant at the 1% level between the large and small cloves in all cases, while in some instances the medium cloves gave a significant increase over the small ones. The Chileno always outyielded the corresponding size of criollo garlic. For

TABLE 3.

Yield of garlic varieties in ton/ha. in comparative experiments. Cortazar, 1958–1959.

Variety	Experiment No. 1	Experiment No. 2
Chileno	5.79	5.21
Criollo	5.29	4.32
Blanco de Jalisco	4.31	3.44
Blanco de Ixmiquilpan	–	3.22
Japonés	–	3.03
L.S.D.—1%	0.51	0.44
—5%	0.36	0.32



Studies of varieties and the most adequate cultural practices have increased the quality and yield of garlic in the Bajío.

the Chileno variety, the average weights of the large, medium, and small cloves were 3.7, 1.5, and 0.8 grams, respectively. For the generally smaller criollo, the corresponding weights were 1.8, 1.2, and 0.7 grams.

In two other experiments, the effect of three sizes of bulbs of the Chileno variety on yield were compared, using all the cloves from the bulbs for planting. In the first experiment, significant differences in yield were found only between the small and large bulbs; there was a gradual increase in production as the bulb used for seed became larger. In the second test, each larger size produced large and highly significant increases in yield.

COTAXTLA

Tomato Improvement

In a replicated yield experiment comparing 4 tomato varieties and 11 lines, the variety Cotaxtla I continued to produce a heavier crop than the others by a highly significant difference. Its yield of 22.6 ton/ha. was followed by that of STEP 272, STEP 260, and Indian River, which produced close to 19 ton/ha. STEP 290 and 284 gave 17 and 16 ton/ha., while Homestead B & L reached 15.6 ton/ha. Rutgers yielded 12.4 ton/ha. Because STEP 272 and 284 are earlier and later, respectively, than Cotaxtla in season, they again seemed to be superior in fruit quality. Indian River, tested for the first time at this location, drew favorable comments and will be retested.

In breeding for resistance to *Phytophthora infestans*, the NH_{24} group of lines again showed a high degree of resistance to field infection and will be used as parental material.

Other Projects

In improvement work on the Serrano pepper variety, further selections were made within four types chosen last year. Jalapeño peppers, also pungent, were under study in another block. Squash line 135A was grown again for further mass selection of the desired type. The collection of cassava varieties was increased to 38 introductions. Slips and vine cuttings of the new Cuitzeo and Catemaco sweet potato varieties were grown for distribution, and 70 pounds of seed of the Cotaxtla I tomato was produced to supply the local demand.

La Campana experimental range station.

Forage Grasses and Legumes

During the past year increased attention was devoted to research activities and development of facilities at the La Campana experimental range station in the semi-arid cattle region of Chihuahua. "Off the station" activities in the tropics, to which a considerable portion of time was given in the past, were reduced in order to complete the establishment of experimental pastures and prepare for the introduction of cattle at Cotaxtla. Many of the original species and variety trials including comparisons over a five-year period were discontinued during the past year in the Mexico City milk-shed region; results and conclusions from most of these studies were summarized in last year's report. Alfalfa improvement and physiology as it relates to cutting management are currently being emphasized. Data are being collected from a limited number of new variety trials in order to compare the new alfalfa variety selections with popular and well adapted introductions.

Range Improvement in Chihuahua

STEER GAINS ON ALKALI SWALE PASTURE

On the alkali swale portion of La Campana containing *Sporobolus airoides* and *Eragrostis obtusiflora* as dominant grasses, two stocking rates, 24 and 16 hectares per animal unit with two replications of each, were included in the 1959 grazing study. Hereford weaner calves averaging 8 months of age at the beginning of the trial in February were considered as half an animal unit (one standard animal unit equals one cow and her calf). Five steers were used in each pasture, the sizes of which varied from 60 hectares for the moderate rate to 40 hectares for the heavy stocking rate. Different supplementary feed rations were given the same animals between February 1 and July 1. Average steer production data are given in Table 1, where only slight differences are noted for the different treatments. The over-all average daily gain of 0.66 kg. was

TABLE 1.

Steer production on an alkali swale pasture site.
La Campana, February 1 to November 1, 1959.

Stocking rate	Supplement[a]	Total av. gain (kg.)[b]	Daily av. gain (kg.)	Gain per ha. (kg.)
Moderate (24 ha./animal unit)	Salt only	193.0	0.71	16.08
	Salt plus cottonseed meal	185.5	0.68	15.46
	Salt plus cottonseed meal plus bonemeal	190.3	0.70	15.86
	Average	189.6	0.70	15.80
Heavy (16 ha./animal unit)	Salt only	165.0	0.60	20.63
	Salt plus cottonseed meal	173.1	0.63	21.64
	Salt plus cottonseed meal plus bonemeal	173.1	0.63	21.64
	Average	170.4	0.62	21.30
Average (20 ha./animal unit)	Salt only	179.0	0.66	18.36
	Salt plus cottonseed meal	179.3	0.66	18.55
	Salt plus cottonseed meal plus bonemeal	181.7	0.67	18.75
	Grand average	180.0	0.66	18.55

[a] Daily ration per head of supplements utilized, in grams:

	Feb.	Mar.	Apr.	May	June
Salt	30	30	30	30	30
Cottonseed meal	500	500	250	250	250
Bonemeal	75	75	75	75	75

During the remaining months all steers had access to salt.

[b] Average initial weight of all animals on February 1, 1959, was 144.7 kg.

considered very good for this alkali pasture site. Growing conditions were very favorable for the maximum development of the native grasses and forage was abundant.

The number of hectares per animal unit for the study now in progress has been reduced to 15 and 10 hectares for the moderate and heavy stocking rates, respectively.

CHEMICAL COMPOSITION OF NATIVE GRASSES

Fifteen native grasses from different grassland regions of Chihuahua were sampled on a monthly basis during 1959 as part of a five-year study to determine the capacity of the native grasses to meet the nutritive needs of breeding cattle. On three different pasture sites at La Campana where samples were collected, total annual rainfall averaged 220 mm., which, although favorable for the growth of grass, was less than average. The rainfall was normally distributed in that the greatest precipitation occurred during July, August, and September, with slight precipitation also recorded for April and October. The general period of active growth of the grasses extended from April through September. The grasses were succulent during the summer and dry and mature during the winter. The highest percentages of crude protein were obtained during the summer and the lowest in winter. The average percentage produced in July, August, and September was 8.06% compared with an average of 5.61% during December, January, and February. During most months of the year, with the exception of a few grasses in summer, the percentages of crude protein were considered to be below the minimum requirements for breeding range cows. The high percentages of nitrogen-free extract obtained even during the winter from dry mature forage verified the presence of a good source of roughage available to grazing animals. The percentages of fat and minerals showed a strong tendency to be highest during the summer and lowest during the winter. The opposite trend was noted for crude fiber percentages. At the present time two important minerals, calcium and phosphorus, are also being determined for each grass and in addition several important browse plants have been included in the study.

ECOLOGICAL RELATIONSHIPS CONCERNING ALFOMBRILLA

As mentioned in previous reports, alfombrilla (*Drymaria arenarioides*), a range plant highly toxic to cattle, has been causing alarming losses to the ranchers of this area. Investigations at La Campana have shown that herbicides are more effective and less costly in controlling alfombrilla than hand hoeing, the method most commonly used by the cattlemen at present. Pending the arrival of this year's growing season for a final evaluation of numerous herbicides for permanent control of alfombrilla, information was compiled concerning the plant's distribution and habitat.

According to the literature, which is very scarce on the subject, alfombrilla has been reported from the States of Sonora, Chihuahua, Zacatecas, and Hidalgo. In Chihuahua, where it is causing the greatest problem to cattlemen, field observations indicate that alfombrilla forms a natural part of the low-growing vegetative strata in a large portion of the grama grasslands of the State. Up to the present, it has been most widely distributed in ranges with an abundance of black grama, *Bouteloua eriopoda*, where the heaviest infestations occur within over-grazed and abused pastures. Its occurrence is generally restricted to an elongated narrow belt extending north and south between the eastern portion of the grama grasslands and the western limit of desert shrub region with an elevation of approximately 1,450 meters above sea level. It thrives on soils of igneous origin in stony hillside sites or in less sloping, well drained, sandy or gravelly pasture sites with soils having a pH from 5 to 7. It does not occur in alkaline soils, although some of the heaviest

Hereford steers at La Campana experimental range station, where stocking rate studies are now in progress.

TABLE 2.

Comparison of yields (ton/ha. of dry matter) of eight tall-growing tropical grasses. Cotaxtla, 1956–1959.

Tropical grass	With supplementary irrigation		Without supplementary irrigation		Average production
	Total production in 3 years	Total number of cuttings	Total production in 3 years	Total number of cuttings	
Merkerón (*Pennisetum purpureum*)	123.08	14	86.92	13	105.00
Japanese cane (*Saccharum sinense*)	92.20	9	63.46	9	77.83
Guinea var. Coloniao (*Panicum maximum*)	60.29	14	57.76	14	59.03
Napier (*Pennisetum purpureum*)	51.59	13	54.83	13	53.21
Guinea var. Privilegio (*Panicum maximum*)	46.08	13	51.67	13	48.88
Honduras (*Ixophorus unisetus*)	42.71	14	32.52	14	37.62
Guinea var. Hoja Fina (*Panicum maximum*)	20.24	10	22.63	10	21.44
Imperial (*Axonopus scoparius*)	14.18	8	7.39	5	10.79
Average	56.30		47.15		51.73

Least significant difference at the 5% level of probability:	
Between 2 grasses (average of both irrigation treatments)	13.00
Between 2 grasses for the same irrigation treatment	18.39
Between 2 irrigation treatments for the same or different grass	28.14
Coefficient of variation in percentage	12.36

infestations occur close to the edge of several alkali swale areas.

PERFORMANCE TRIALS OF GRASSES AND LEGUMES

MEDIUM RED CLOVER

Medium red clover has demonstrated its excellent adaptation to the cold, humid climate of the Valley of Toluca at an elevation of 2,675 meters above sea level. On the basis of preliminary observations it was immediately recommended to dairy farms in the Valley and similar regions. Two years' data from a more recent trial further indicated the superiority of medium red clover. The Kenland variety in two years of cutting produced a total of 48 ton/ha. of hay which was double the yield of the adapted alfalfa varieties in the same trial. Although Ladino clover was well adapted and showed good persistence, its total hay yield in two years was about 10 ton/ha. less than that of Kenland red clover.

The original planting of Kenland red clover in a small yield trial established in December, 1952, is still producing good forage yields. At the termination of six years of cutting, Kenland red clover has yielded a total of 135.15 ton/ha. of hay in 27 cuttings. Its total yield in the sixth harvest year was 14.5 ton/ha. These results indicate the true perennial growth habit of medium red clover in the absence of diseases and severe winters, in contrast with its normal growth habit in the red-clover producing areas of northern United States and eastern Canada, where the species behaves as an annual or biennial.

MERKERON

Eight tropical grasses, well suited for making silage or soilage, have been compared for a period of three harvest years, 1956–1959, at Cotaxtla (Table 2). The experiment was designed so as to enable comparisons of grasses grown both with and without the aid of supplementary irrigation. Merkerón, with and without irrigation, yielded significantly more dry matter than all other grasses in terms of total amount of forage produced in three years. Its average yield was twice that of common napiergrass, another variety of the same species, *Pennisetum purpureum*. During the 1956–1957, 1957–1958, and 1958–1959 harvest years, 4, 3, and 5 irrigations were applied, respectively. The general response to supplementary irrigation was not great, and only Merkerón and Japanese forage cane produced significantly higher yields with irrigation.

JARAGUA

Data were obtained for a period of three harvest years in another yield trial at Cotaxtla containing tropical grasses which, because of their growth habit, are best suited for grazing. In this test Jaragua has proven to be the highest yielding and one of the best adapted grasses, as shown in Table 3. Jaragua produced significantly higher yields than all other grasses under supplementary irrigation and was significantly better than six of the seven grasses without irrigation. Other well-adapted grasses were buffel, Guinea, and pangola. Many of these same grasses have now been established in experimental pastures for more precise evaluation under grazing conditions. Molassesgrass, Bermudagrass, Rhodesgrass, and blue panicgrass were completely unproductive during the third harvest year because of poor stands.

ESTABLISHMENT AND MANAGEMENT OF IMPROVED PASTURES

Six introduced tropical grasses—pangola, alemán, pará, Guinea, Merkerón, and Jaragua—have been successfully established in approximately 50 hectares at Cotaxtla. In addition to these six grasses, four other introductions have been established in a cafeteria-type grazing experiment. The weighing station, corrals, and pasture divisions are being constructed at the present time.

TABLE 3.

Comparison of yields (ton/ha. of dry matter) of eight tropical grasses well suited for grazing. Cotaxtla, 1956–1959.

Tropical grass	With supplementary irrigation		Without supplementary irrigation		Average production
	Total production in 3 years	Total number of cuttings	Total production in 3 years	Total number of cuttings	
Jaragua (*Hyparrhenia rufa*)	53.69	15	50.25	14	51.97
Buffel (*Pennisetum ciliare*)	45.26	17	44.32	16	44.79
Guinea var. Privilegio (*Panicum maximum*)	42.11	14	39.46	13	40.79
Pangola (*Digitaria decumbens*)	33.53	11	35.33	10	34.43
Molasses (*Melinis multiflorum*)	37.18	9	22.71	9	22.92
Bermuda (*Cynodon dactylon*)	21.58	17	18.65	12	22.14
Blue panic (*Panicum antidotale*)	13.93	12	14.25	12	14.08
Rhodes (*Chloris gayana*)	12.07	8	10.63	8	11.35
Average	31.17		29.45		30.31

Least significant difference at the 5% level of probability:	
Between 2 grasses (average of two irrigation treatments)	4.74
Between 2 grasses for the same irrigation treatment	6.70
Between 2 irrigation treatments for the same or different grass	10.16
Coefficient of variation in percentage	7.74

Collecting pollen from a native Mexican variety for use in crosses.

Potatoes

Late blight of potatoes, caused by the fungus *Phytophthora infestans*, is the most important disease problem confronting the potato growers of the world. The control of this pathogen is one of the most costly items in the production of a potato crop. In many parts of the world the potato is grown on a very limited scale or not at all, owing to the high costs of protection against *P. infestans* or to the annual risk of heavy or total loss of the crop if inadequate measures are practiced.

In Mexico, the potato has been cultivated primarily in the high mountains, or during the winter under irrigation, to escape the ravages of late blight. As a result, this important basic food crop has never realized its potential in the diet of the Mexican people.

The key to the solution of this problem lies in the creation of new potato varieties, resistant to the late-blight disease, which can be cultivated in Mexico under conditions of natural rainfall, with no protection from fungicidal sprays, and which will produce satisfactory yields of commercially acceptable tubers. The potato section of the OEE has now produced and named a series of such varieties, which are being multiplied and distributed to farmers as rapidly as possible.

BREEDING PROGRAM

In this program, the three following sources of genetic material carrying characteristics for late-blight resistance and tuber quality are being utilized: (1) selections that have demonstrated resistance during past years at the Santa Elena station, (2) commercial foreign varieties with known characteristics of high quality, and (3) wild Mexican varieties —Amarilla de Puebla, Amarilla Criolla, and Leona del Perote. Material utilizing these three large groups of germ plasm is planted annually at Santa Elena, where environmental conditions are favorable for the development of *P. infestans* and where very rigorous selection for resistance can be practiced.

In the summer of 1958, 7,087 clones were planted at Santa Elena, from which 807 selections with outstanding resistance to late blight were made. Of these 807 selections, 673 were tested in 1959, considerable selection for storage characteristics having been made between planting seasons. Potato varieties recommended for planting in Mexico must be slow germinators under nonrefrigerated storage conditions, since this is the type of storage which the average farmer has immediately available. As a result of further study of the 673 clones, only 227 selections were retained, of which 75 were planted out in special observation plots this year for more detailed observation of their characteristics of resistance and quality and, later, their storage ability. Data for eight of the most outstanding selections made during 1958 and 1959 are listed below.

Line number	Late-blight reading[a]	Av. yield (kg./ha.)
57–AO–5	2	3.1
57–BD–5	2	3.0
57–BK–62	1	2.0
57–BL–3	2	2.0
57–BP–11	2	2.3
57–CT–40	2	2.0
57–DZ–30	2	2.4
57–EA–3	2	2.0

[a] Scale of 1 = most resistant, 5 = most susceptible.

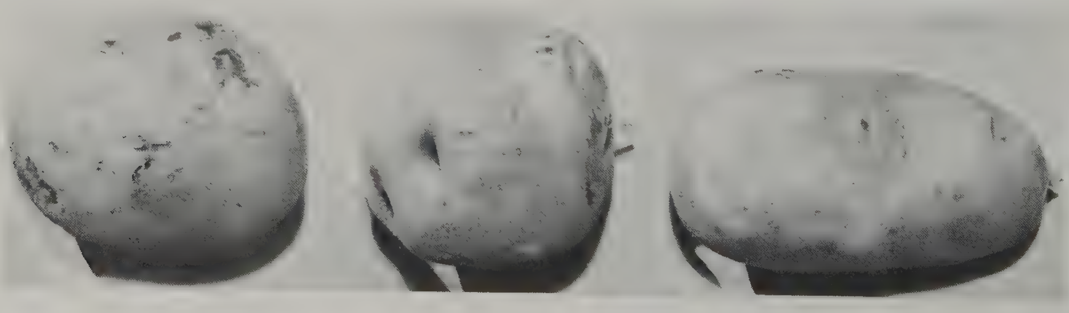
NEW BLIGHT-RESISTANT VARIETIES

Nine new varieties of potato (Anita, Bertita, Conchita, Dorita, Elenita, Eréndira, Florita, Gabriela, Greta) have been named and released to be grown during the summer under natural rainfall in the Mesa Central of Mexico. These new varieties have demonstrated a high level of resistance to late blight, sufficient to produce a good harvest without applications of fungicides to the foliage. The farmer can thus plant them with a minimum cost of production. The resistance which these nine new varieties possess was obtained by means of a crossing program between commercial varieties and selections, and the wild Mexican species, *Solanum demissum*. It is of the multigenic type which, over a period of almost eight years in trial plots at El Horno and Santa Elena, has demonstrated satisfactory yields.

In addition to being highly resistant to late blight, the new varieties sprout very slowly after harvest and can be stored in unrefrigerated warehouses until the next planting season. This characteristic also makes it possible for the farmer to hold his harvest for several months to take advantage of best market conditions. Agronomically these varieties are highly acceptable, and in visual aspect and cooking qualities they are very similar to the European varieties, which are well known in the national market. Yields of the new varieties vary, depending upon the region; with adequate fertilization, yields of from 20 to 30 ton/ha. have been obtained in the States of México and Michoacán. Under experimental conditions, yields have been greater, but nevertheless a conservative yield of 20 ton/ha. may be expected in practice.

A number of selections and varieties resistant to late blight were tested in large-scale yield trials at Santa Elena in 1959. No fungicidal spray was applied to the test plots. The newly released varieties Bertita, Eréndira, Conchita, and Anita yielded 46, 44.3, 34.3, and 32.6 ton/ha., respectively. The commercial variety Alpha, used as a check, yielded only 7.2 ton/ha., and tubers from this variety were very small and not of commercial size.

Three new late-blight-resistant potato varieties: (left to right) Conchita, Anita, Bertita.



TESTS OF FUNGICIDES

During 1959, trials were conducted with eight fungicides available in the Mexican market and a new product called Brestan, for control of late blight. The summer season last year was particularly favorable for the development of the disease. As shown in Table 1, manzate (maneb) gave the best protection against late blight, and Brestan ranked third of the materials tested.

YIELD TRIALS

The potato section conducts annual trials to study the yield of commercial varieties from other parts of the world. At El Horno in 1959, 49 such varieties were tested. Loman, Riemersma, Industrie, and Alpha were outstanding in these trials, each yielding approximately 40 ton/ha. The varieties Bea, White Rose, Katahdin, and Royal Kidney yielded approximately 20 ton/ha. each. Commercial fungicides were used to protect the varieties from late blight.

TABLE 1.

Effectiveness of three fungicides for control of late blight. El Horno, 1959.[a]

Treatment	Yield (ton/ha.)
Manzate—Dust 13%	36.9
Manzate—2.2. lb./105 gal.	34.6
Brestan—2.2 lb./105 gal.	32.6
Check	4.6
L.S.D.—5%	5.46

[a] The potato variety used was Up-to-Date.

Taking soil samples to determine moisture conditions.

Soil Fertility and Management

Investigations in soils are directed toward the determination of economical means of making the soil a more favorable medium for plant growth. The soil properties which most commonly limit crop yields in Mexico—nitrogen, phosphorus, and moisture—have continued to receive major attention. Research on the residual effects of cropping practices on soil productivity has been continued.

The soil fertility studies were carried out at the El Horno, Santa Elena, Cotaxtla, and CIANO experiment stations, and in cooperation with farmers in the State of Guanajuato and in the Yaqui Valley, Sonora. Most of the studies were made with corn, wheat, potatoes, and cotton, but some involved beans, alfalfa, sesame, and sorghum. Soil moisture studies were conducted with wheat on a private farm in the Bajío and at CIANO.

In the following pages studies are reported on potato fertilization in an important potato-producing area of the Bajío, alfalfa fertilization in the Valley of Mexico, and the management of tropical legumes for use as green manure crops in the State of Veracruz. The work on these subprojects has progressed to the point where it is possible to draw fairly reliable conclusions.

POTATO FERTILIZATION

During the spring of 1958 and 1959, 30 experiments were conducted to determine the fertilizer needs of potatoes in the León, Guanajuato, area. Three important soil conditions were studied: (1) heavy, grey soils with blocky structure (north of the Mexico City—León highway), (2) heavy, black soils with granular structure (south of the highway), and (3) light-grey, silty clays (southeast of León). The experiments were distributed so that the fertilization of potatoes was studied in plantings (1) immediately following the incorporation of alfalfa, (2) following corn in land without alfalfa for at least two years, and (3) following corn but with a heavy application of barnyard manure just prior to planting potatoes.

It was found that the response of potatoes to nitrogen fertilization was similar for the three soil conditions. The response to nitrogen was, however, markedly affected by the cropping history of the soil. The average increases in the yields of potatoes with the application of different amounts of nitrogen per hectare in plantings following corn, alfalfa, and corn plus manure are shown graphically in Figure 1. Applications of nitrogen increased yields most in plantings following corn and least in plantings following corn plus manure. Intermediate increases due to nitrogen fertilization were observed in plantings following alfalfa. Evidently the liberation of nitrogen with the decomposition of the alfalfa residues and the manure supplied appreciable amounts of nitrogen to the potatoes. It is interesting to note, however, that even after the incorporation of alfalfa stubble and large amounts of manure, potatoes responded to an additional application of 60 and 40 kg. of nitrogen per hectare, respectively. The three curves in Figure 1 have well-defined maxima. This indicates that the over-fertilization of potatoes with nitrogen results in significant reductions in yield.

The response of potatoes to phosphorus fertilization was quite different in the grey soils with blocky structure and the black soils with granular structure. The average effect of the application of 60 kg. of P_2O_5 per hectare was a yield increase of 1.2 ton/ha. in the former and 3.2 ton/ha. in the latter. In past years the black soils with granular structure have received less fertilizer and manure than the grey soils with blocky structure, and perhaps for this reason responded more to phosphorus fertilization.

Differences due to cropping history were also noted in the amount of phosphorus required for optimum production. The amount needed was greatest in plantings following alfalfa, intermediate in plantings following corn, and least in plantings following corn plus manure. When potatoes are planted following alfalfa the soil has probably received no phosphorus since the alfalfa was seeded about three years earlier; in plantings following corn, the soil usually has been fertilized with phosphorus the two preceding years. Thus, the smaller phosphorus requirement following corn probably reflects a greater residual effect from earlier applications. The amount of phosphorus needed following corn plus manure was small, as considerable phosphorus was supplied through the decomposition of the manure.

Potato yields were not increased significantly by the application of potassium, and the addition of 80 kg. of K_2O per hectare decreased yields significantly in three experiments. The average effect of applying 40 kg. of K_2O per hectare was a small reduction in yield in the grey soils with blocky structure and a small increase in yield in the black soils with granular structure. The average effect of applying 80 kg. of K_2O per hectare was a small reduction in yield in all soils.

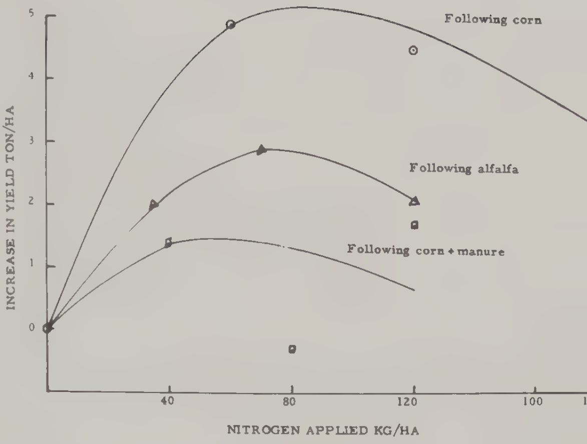


Figure 1. Average increases in the yield of potatoes from nitrogen fertilization in plantings following corn, alfalfa, and corn plus manure.

A study of the results from the 30 experiments permitted the formulation of tentative fertilizer recommendations for potatoes in the León, Guanajuato, area. These are presented in Table 1.

Alfalfa Fertilization

A study of the effects of applications of phosphorus and barnyard manure on the production of alfalfa has been in progress at the El Horno station for three years. The production of dry alfalfa during the three-year period with the application of different amounts of P_2O_5 is shown in Figure 2. Yields were increased from 49.45 to 63.39 ton/ha. or by 28% with the application of 160 kg. of P_2O_5 per hectare; that is, each kg. of P_2O_5 increased yields by 87 kg. of dry alfalfa. An economic analysis of the curve in Figure 2 shows that, at present prices, the most eco-

TABLE 1.

Fertilizer recommendations for potatoes in the León, Guanajuato, area.

Soil condition	Previous crop		
	Alfalfa	Corn	Corn and manure
Heavy, grey soils with blocky structure	60-100- 0	80- 80- 0	40-40- 0
Heavy, black soils with granular structure	60-120-40	80-100-40	40-60-40
Light-grey, silty clays	60-120- 0	80-100- 0	40-60 -0

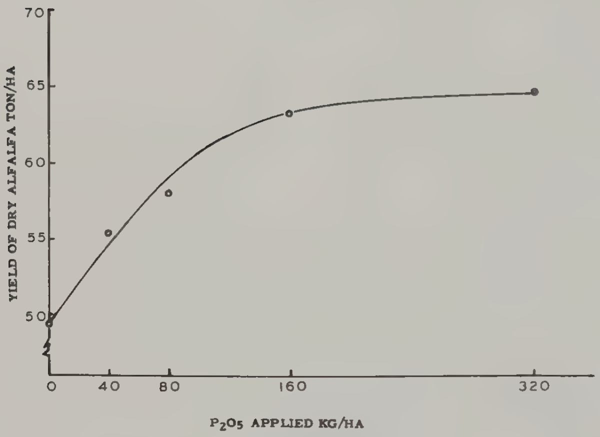


Figure 2. The production of alfalfa during a three-year period with the application of different amounts of phosphorus.

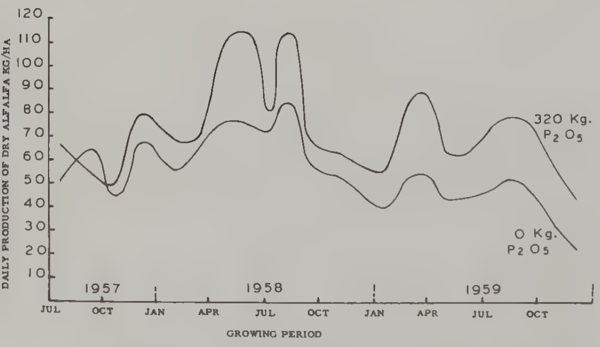


Figure 3. The daily production of alfalfa during 1957–1959 in plots fertilized with 0 and 320 kg. of phosphorus per hectare.

nomical rate of fertilization under the conditions of this study is 210 kg. of P_2O_5 per hectare.

The increase in yield of alfalfa due to the application of phosphorus became larger as the age of the alfalfa planting increased. This is illustrated in Figure 3, which shows the daily production of dry alfalfa in plots receiving 0 and 320 kg. of P_2O_5 per hectare throughout the three-year growing period. It may also be noted in Figure 3 that the increase in alfalfa yield due to the application of phosphorus was greatest in periods like April, May, and August in 1958, and March, April, August, and September in 1959, when production was at a maximum. This suggests that maximum increases due to phosphorus fertilization may be expected when other productivity factors are optimal.

The production of alfalfa with the application of 10 and 40 tons of manure per hectare was measured. When increases in alfalfa production due to applications of manure and phosphorus were compared, it was found that each ton of manure increased yields by an amount approximately equivalent to 3.3 kg. of P_2O_5 added in the form of calcium superphosphate.

A comparison was made of the effectiveness of applying all of the phosphorus at planting time and applying one-third at planting time, one-third a year later, and one-third two years later. The application of all the phosphorus at planting time was 30% more effective.

TABLE 2.

Effect of the stage of growth of three tropical legumes at the time of incorporation into the soil on the amount of organic matter and nitrogen added and the yield of the following corn crop.

No. of treatment[a]	Growth period (days)	Green weight (ton/ha.)	% dry matter	Dry weight (ton/ha.)	% nitrogen in legumes	Amount of nitrogen incorporated (kg./ha.)	% nitrogen in corn grain	Yield of stalks (ton/ha.)	Yield of ear corn (ton/ha.)
				JACK BEAN					
1	–	–	–	–	–	–	1.45	4.80	3.99
2	–	–	–	–	–	–	1.71	5.37	5.11
3	66	7.72	13.6	1.15	3.48	39.5	1.52	5.34	4.77
4	100	15.17	17.4	2.64	3.00	78.5	1.64	6.67	4.90
5	144	18.28	20.1	3.64	3.29	118.9	1.65	6.28	5.02
6	198	10.35	33.2	3.43	2.29	79.4	1.59	5.55	3.93
L.S.D. at 5%								0.91	0.98
				CROTALARIA					
1	–	–	–	–	–	–	1.47	6.16	4.25
2	–	–	–	–	–	–	1.78	6.21	5.31
3	53	20.18	15.4	3.10	1.83	57.7	1.57	6.58	5.00
4	71	25.27	19.1	4.80	1.76	84.7	1.66	7.76	5.11
5	94	24.76	23.7	5.86	1.52	89.7	1.54	6.54	5.19
6	162	22.10	34.7	7.67	1.26	97.6	1.71	6.90	4.97
L.S.D. at 5%								1.58	0.56
				VELVET BEAN					
1	–	–	–	–	–	–	1.32	4.99	3.88
2	–	–	–	–	–	–	1.73	5.09	5.07
3	71	14.93	13.5	2.02	3.35	67.7	1.59	5.15	4.89
4	100	17.62	14.3	2.53	2.99	75.6	1.48	5.72	4.84
5	130	20.56	18.7	3.85	2.88	111.2	1.59	6.01	4.50
6	160	9.43	35.3	3.32	2.60	86.1	1.49	5.43	4.82
L.S.D. at 5%								NSD	0.96

[a] Description of the treatments:

1. No legume; without nitrogen.
2. No legume; corn fertilized with 80 kg. of nitrogen per hectare.
3. Legumes turned under before flowering.
4. Legumes turned under in full flower.
5. Legumes turned under when the first pods matured.

TROPICAL LEGUMES AS GREEN MANURE CROPS

In 1958–1959 an experiment was carried out at the Cotaxtla station to study the effect of the stage of development of legumes at time of incorporation on the amount of dry matter and nitrogen added to the soil and on the yield of the following corn crop. Velvet bean (*Stizolobium deeringianum*), jack bean (*Canavalia ensiformis*), and Crotalaria (*Crotalaria juncea*) were planted in September, 1958, in separate experiments. The legumes in the experiments were incorporated into the soil at four stages of development: (1) before flowering, (2) in full flower, (3) when the first pods matured, and (4) at vegetative maturity. Sufficient moisture was present in the soil for rapid decomposition for one month following the incorporation of the legumes. The three experimental blocks were planted to corn in May, 1959. Treatments without nitrogen and with 80 kg. of nitrogen per hectare were included in each experiment, utilizing plots not previously employed in producing legumes.

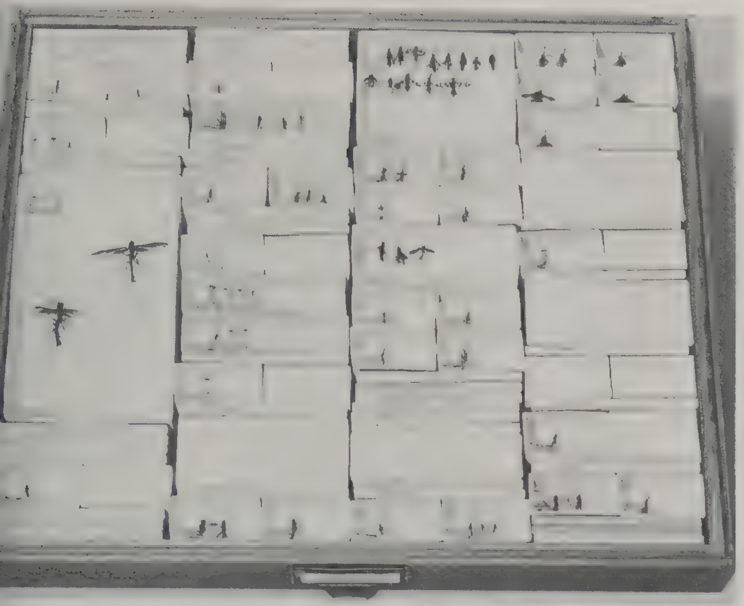
The amounts of green matter, dry matter, and nitrogen incorporated into the soil and the production of corn in plots with and without the incorporation of legumes are shown in Table 2. The maximum amounts of dry matter produced by velvet bean and jack bean were similar and were slightly more than half that produced by Crotalaria. The nitrogen percentages, however, were much higher in the velvet bean and jack bean than in the Crotalaria.

The amount of dry matter added to the soil varied with the stage of growth at time of incorporation. The amounts added by the velvet bean and jack bean were greater when the legumes were incorporated at the time the first pods matured. When these legumes matured before being turned under, yields were slightly less, probably because of the loss of leaves. In the case of Crotalaria, the largest amount of dry matter was added to the soil when the legume was incorporated after maturity.

The nitrogen percentages in the legumes were highest in the young growth and decreased progressively as the legumes developed. Largest amounts of nitrogen were added to the soil when velvet bean and jack bean were incorporated at the time the first pods matured and when Crotalaria was incorporated after maturity.

Ear corn yields were about 4 ton/ha. without the addition of nitrogen or the incorporation of legumes. The application of 80 kg. of nitrogen per hectare increased yields slightly more than 1 ton per hectare. The incorporation of the three legumes at all stages of growth (except mature jack bean) increased corn yields by comparable amounts. The average effect of the incorporation of the legumes on grain yields was approximately equivalent to that of 60 kg. of nitrogen per hectare in the form of sulfate of ammonia.

The value of a green manure crop is largely determined by the amount of humus it adds to the soil and its effect on the yield of the following crop. When the nitrogen percentage is greater than 1.5, the amount of humus produced is roughly proportional to the amount of dry matter added. Therefore, it is probable that the best time to incorporate velvet bean and jack bean is when the first pods mature. The proportion of dry matter converted to humus decreases as the nitrogen percentage decreases in materials containing less than 1.5% nitrogen. For this reason, it seems likely that similar amounts of humus will result from the incorporation of Crotalaria when the first pods mature or at vegetative maturity.



One of the 305 drawers in the reference collection at El Horno illustrating the arrangement now in use.

Entomology

During 1959–1960 the research directed toward the development of efficient means for the control of damaging insects in Mexico was centered at El Horno, CIANO, and Cotaxtla. This report, though not all-inclusive, presents the most interesting highlights of the year's work.

INSECT COLLECTION AND SURVEY

Late in 1959 a check list of the reorganized reference insect collection at El Horno was published and distributed to interested entomologists throughout the world. This listing summarizes information on the some 30,000 specimens contained, representing 267 families of Insecta and including material from the Cotaxtla and CIANO research centers. It is hoped that this list will stimulate others and help to form a basis for future catalogues covering the distribution of insect species within Mexico.

Routine collections of injurious insects and their parasites and predators were continued during the past year, with special emphasis at Cotaxtla and CIANO. Important highlights were the confirmation of the presence of the Delphacid vectors of the "hoja blanca" disease of rice, *Sogata orizicola* Muir and *S. cubana* (Crawf.), at Cotaxtla and the appearance of a damaging thrips, *Hercothrips phaseoli* (Hood), on soybeans at CIANO.

New reports of insect parasites included a wasp, *Heterolaccus grandis* Burks, attacking the cotton boll weevil and the Tachinid flies, *Gymnocarcelia ricinorum* Tms. and *Exorista* sp., parasitizing the salt-marsh caterpillar, *Estigmene acrea* (Drury), in the Northwest.

BIOLOGICAL AND ECOLOGICAL STUDIES

BANDED CUCUMBER BEETLE

During the spring of 1959 detailed insectary studies and field observations were conducted at Cotaxtla on the biology of the banded cucumber beetle, *Diabrotica balteata* Lec., one of the two principal pests of beans in the Veracruz area. In the insectary this insect completed its development from newly deposited egg to newly emerged adult in the average time of 36 days, with variation extremes of 28 and 48 days. The adult beetles matured and initiated egg deposition after 18 days and lived 23 days, depositing an average of 101 eggs. These data were confirmed in the field and indicate approximately six overlapping generations per year. Adult *D. balteata* prefer bean foliage for feeding but are attracted principally to small corn plants in recently irrigated plots for egg deposition. The developing larvae have caused most severe damage to corn roots in winter plantings where large adult populations have been attracted to irrigated fields from the surrounding dry areas.

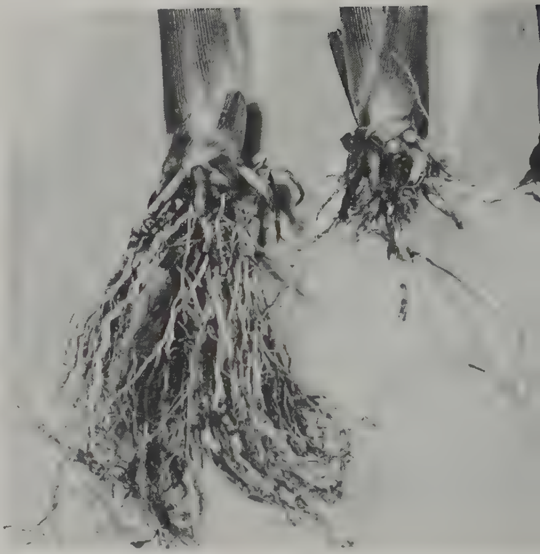
SOLDIER FLY

At the Cotaxtla station, excellent control of house flies in poultry manure under caged laying hens has resulted from the presence of large larval populations of the soldier fly, *Hermetia illucens* L. Preliminary to attempts at the establishment and management of this insect in poultry houses in other locations at higher altitudes, a detailed study of its biology was conducted in the insectary and greenhouse at El Horno, where this species does not occur and isolation from the natural population is possible.

When *H. illucens* was reared on fresh poultry manure, an average of 60 days was required for development from freshly deposited egg to newly emerged adult stage. Female flies required 9 days to reach sexual maturity, when they deposited masses that averaged 250 eggs. Ninety-five per cent of eggs deposited produced apparently normal larvae. Observations at Cotaxtla indicate that the biology of this species is similar at that location.

BEAN WEEVIL

A less detailed study was carried out at El Horno on the bean weevil, *Spermophagus pectoralis* (Say), preliminary to a test to determine the relative susceptibility in storage of ten different bean varieties to this insect. Under optimum conditions within a special rearing cabinet this Bruchid completed its biological cycle in 23 days.



Corn roots from Cotaxtla (right) show severe larval damage by the banded cucumber beetle, *D. balteata;* root at left is relatively uninjured.

STORAGE PESTS IN CORN AT HARVEST

To gain a better understanding of the levels of infestation by storage pests in corn at harvest, and the factors that influence these infestations, special studies were conducted at El Horno in fall-harvested corn and in the tropics at Cotaxtla in a May harvest.

At El Horno in the more temperate climate, a recommended hybrid (H–24), a native variety, and a white flour corn averaged 1.6%, 5.6%, and 9.4% infested ears, respectively. These differences were associated principally with tightness and length of husk cover. The most prevalent insects were the Angoumois grain moth, *Sitotroga cerealella* (Oliv.), the larger grain borer, *Prostephanus truncatus* (Horn), and the rice weevil, *Sitophilus oryza* (L.). Unfumigated samples of corn stored for five months were found to have 30% of the grains damaged by these insects, while samples fumigated at harvest had less than 4% damage after the same time in storage. These results clearly demonstrate that a fumigation is needed early in the storage period to kill the internal insect infestation in freshly harvested corn in the Valley of Mexico.

At Cotaxtla, 28 days after harvest first generation adults of the rice weevil, *S. oryza*, the most prevalent insect, averaged 15.9 per ear in H–503, the presently recommended hybrid, as compared with 0.9 insects per ear in the native variety. This difference is due for the most part to the more complete husk covering on the native corn, and indicates the value of a long tight husk cover in the protection of corn from field insect infestation.

EFFECT OF ALTITUDE ON STORAGE PESTS

The relationships between grain temperature and insect development are well known. In Mexico, the large variations in altitude markedly influence air temperatures and thus create variations in temperature within grain storage deposits at different locations. Predictions of possible damage by storage pests and recommendations for their control must be based on quantitative data on the development of these pests at representative altitudes. In July of 1959 Dr. Donald A. Wilbur of the Department of Entomology, Kansas State University, joined the section to aid in the orientation of studies designed to obtain this ecological information.

Work was begun to measure the rate of development and damage caused by four of the major pests, the granary weevil, *Sitophilus granarius* (L.), the rice weevil, *S. oryza*, the larger grain borer, *P. truncatus*, and the lesser grain borer, *Rhizopertha dominica* (F.), at five locations: Cotaxtla, Ver. (sea level), Cuautla, Mor. (4,200 ft.), Cortazar, Gto. (5,930 ft.), Chapingo, Méx. (7,451 ft.), and Toluca, Méx. (8,793 ft.). Records of population development and resulting grain damage were made at monthly intervals from October through February. As was expected, most rapid development and severe grain injury occurred at the three locations below 6,000 feet. At Chapingo (El Horno) where temperatures are milder, development of these insects was retarded; and at Toluca (Santa Elena) where the temperature of uninfested grain averaged 59°F., all four species of insects failed to reproduce. These results clearly demonstrate that grain storage is most difficult in the lower altitudes, while above 6,000 feet, where air temperatures are considerably cooler, efficient storage can be most easily and economically accomplished.

An extremely large population of rice weevils, *Sitophilus oryza*, in commercial corn stored at Santa Elena. Even at this relatively cool location the control of storage pests is essential.

Even at the higher altitudes, however, insect control practices are usually necessary, since the temperature changes very slowly in large grain masses. Warm harvest temperatures, favorable for insect development, may be maintained in a large quantity of grain for several months. This fact was confirmed at Santa Elena by a complementary study in which temperature records were taken above and within a 4,000-ton mass of wheat in a large government warehouse. Temperatures in the center of the wheat, extending to 1 meter below the surface, varied between 87° and 90°F. from September through December. These temperatures, favorable for insect development, were maintained even though the temperature above the grain was as low as 59°F. at times and minimums of 15°F. were recorded outside the warehouse. A mechan-

Recording temperatures above and within a large mass of wheat in the ecological study being conducted at the Santa Elena station.

ical means to move this cool air through the grain would have prevented the build-up of four different species of insects that occurred in this wheat. The discovery of several thousand tons of corn severely damaged by the rice weevil, *S. oryza*, in another warehouse at Santa Elena added further evidence that control measures for storage pests are necessary in the cool regions as well as at warmer, low-altitude locations.

Chemical Control Studies

PESTS OF CORN

In summer corn at Cotaxtla two spray applications of endrin (0.08–0.15 kg./ha.), thiodan (0.5–1.0 kg.), and Dipterex (0.6–1.2 kg.) gave good control of the fall armyworm, *Laphygma frugiperda* (J. E. Smith). Three applications of these same materials and the additional materials diazinon (0.1–0.4 kg.) and Metasystox (.05–0.2 kg.) failed to control the neotropical corn stalk borer, *Zeadiatraea lineolata* (Wlk.), or to reduce populations of the corn stunt vector, *Dalbulus maidis* (DeL. & W.), sufficiently to reduce incidence of the disease. The fact that control of the fall armyworm was not reflected in increased yields of corn confirms the earlier conclusion that the use of insecticides is practical only in very small corn in the Cotaxtla area.

In the spring planting at CIANO, Thimet and Di-syston, two systemic insecticides applied to seed before planting at the rate of 6% and 4% by weight, gave partial control of thrips, *Frankliniella occidentalis* (Perg.), but failed to reduce populations of a flea beetle, *Chaetocnema* sp., or to increase the final yield of corn. Endrin (0.1 kg./ha.), methyl parathion (0.3 kg.), and toxaphene (0.6 kg.) applied three times to the foliage in sprays gave only partial control of these same insects and did not improve yields.

In summer plantings at CIANO, two and three applications of endrin (0.1 kg.) gave good control of the fall armyworm and increased yields 18% and 26%, respectively. In a second test, two applications of Sevin (1.0 kg.), Dipterex (1.0 kg.), and Shell-50 (0.3 kg.) in sprays, and a granular formulation of endrin (0.3 kg.) were equally as effective as endrin (0.1 kg.) spray, the current recommendation, in controlling this insect and in increasing production as much as 50%, clearly an economic gain.

CORN LEAF APHID ON BARLEY

In fall-planted barley at CIANO, two sprays of Metasystox (0.2 kg.), methyl parathion (0.6 kg.), and malathion (1.3 kg.) effectively reduced populations of the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), in small plants. As no significant differences in yield were observed between treatments, it is assumed that the plants in check plots recuperated from the early season aphid damage.

PESTS OF SOYBEANS

During the summer months, in the Yaqui Valley a severe outbreak of thrips, *H. phaseoli*, occurred on soybean, a recently introduced crop in the area. Control was obtained in commercial fields with toxaphene. Later in the season, some fields were defoliated by the salt-marsh caterpillar, *E. acrea*, which was controlled with Dipterex. Fields where these two insects were not effectively controlled yielded about ½ ton less per hectare than treated fields. More detailed investigation with these pests is in progress.

SWEET POTATO BORERS

At Cotaxtla, larvae of two different species of boring insects have damaged sweet potatoes, a Cerambycid beetle in the tubers, *Stenygra histrio* Serv., and a Pyralid moth, *Sylepta elevata* Fab., in the stems just above ground level. During the summer of 1959 a detailed chemical control experiment was conducted at this station in cooperation with the horticulture section to test the effectiveness of heptachlor (3 kg./ha.) and dieldrin (3 kg.) pre-planting soil treatments in combination with two, three, and five sprays of DDT (1.5–2 kg./ha.) applied to the foliage for the control of these borers.

Stem borer infestation was reduced by both soil and foliage treatments. In untreated plots more than 80% of stems sampled were tunneled, while three applications of DDT reduced this damage to 60%, heptachlor in the soil to 44%, and the combination of these two treatments to 22%. Dieldrin in the soil was less effective than heptachlor. Yields were not influenced by stem borer injury in this trial.

Tuber borer damage was not reduced by the DDT sprays, but the soil treatments did limit the low population present of this insect, reducing tuber injury from 7% to levels below 1%. The heptachlor pre-planting treatment is currently being recommended for the control of both these borers.

SPOTTED ALFALFA APHID

At CIANO in the spring of 1959, good control of the spotted alfalfa aphid, *Therioaphis maculata* (Buckton), resulted from two spray applications of ethyl parathion (0.06–0.2 kg./ha.), methyl parathion (0.06–0.2 kg.), Metasystox (0.06–0.2 kg.), and malathion (0.5–1.4 kg.). All increased yields of green alfalfa in the following cutting by about 5 tons. At present malathion and Metasystox are being recommended for the control of this aphid in the Yaqui Valley as well as in the Valley of Mexico.

PESTS OF STORED GRAIN

Fumigation tests were continued at El Horno in the laboratory to measure the relative efficiency of Dowfume 75 (ethylene dichloride 70.2%, carbon tetrachloride 29.8%) and Dowfume EB–5 (ethylene dichloride 29.2%, ethylene dibromide 7.2%, carbon tetrachloride 63.6%) in killing the different biological stages of the granary weevil, *S. granarius*, the rice weevil, *S. oryza*, and the confused flour beetle, *Tribolium confusum* Duv. In general, *S. granarius* was most resistant to these fumigants. *T. confusum* was most susceptible and *S. oryza* was intermediate in reaction. Prepupae and pupae of *S. granarius* were the most resistant forms, and it can be assumed that concentrations of fumigants that will kill these two forms will control all other forms present. Since Dowfume 75 and EB–5 are of relatively low toxicity and are liquids easily handled at room temperature, they are being recommended for use in small storages on the farm.

The application of insecticides such as malathion, methoxychlor, or lindane to commercial grain to prevent insect attack cannot be recommended in Mexico, as in other countries, because there are no official tolerances for toxic residues and no consumer protection agency to enforce them. To search for effective grain protectants of still lower mammalian toxicity, a cooperative project has been initiated with the Department of Entomology of the Graduate School at Chapingo. Preliminary results indicate that S.G. 68, a nontoxic silica aerogel material that kills insects by adsorption of body covering and subsequent dehydration, is a very effective grain protectant both in the tropics at Cotaxtla and at Chapingo. Further evaluation of S.G. 68 and other possible protectants is planned.

Biological Control Studies

PASTURE SPITTLE BUG

The spittle bug, *Aenolamia postica* (Walk.), and the related species *Prosapis simulans* (Walk.) have at times caused heavy damage to pasture grasses along the Gulf Coast. In sugar cane, insecticides are used to control these pests, but this means of control is not practical in pastures. During 1959 a special survey was conducted by Dr. D. C. Lloyd, of the Commonwealth Institute of Biological Control, to search for native parasites and predators of the spittle bugs in the Gulf Coast area. Assistance was supplied by entomologists from the Mexican Institute for the Improvement of Sugar Cane Production and the OEE.

The results of the survey were in general disappointing. About 1% of spittle bug nymphs were attacked by a Syrphid fly larva, *Salpingogaster nigra* Schiner, in all areas visited except Tabasco, and up to 7% of nymphs in the Córdoba, Ver., area were parasitized by a nematode, *Hexameris* sp. Two Reduviid bugs, *Castolus plagiaticollis* Stal. and *Zelus* sp., and various species of Salticid spiders were observed in small numbers attacking the adults. Two fungi have previously been reported to attack adults but these, *Metarrhizium anisopliae* Metsch. and *Empusa* sp., were not observed during the 1959 season. No egg parasites were found or have been reported from Mexico. It appears that the parasite-predator complex attacking spittle bugs in Mexico is limited in size and effectiveness, as is the case in other countries. These results give further support to the conclusion that long-range ecological studies, with emphasis on plant resistance and grass management practices, are the most promising means of developing measures to reduce damage by these spittle bugs to tropical grasses in Mexico.

CONTROL OF HOUSE FLY BY SOLDIER FLY

The results of a laboratory study at El Horno indicate that the efficient control of the house fly larvae by larvae of the soldier fly, *H. illucens*, in manure under caged hens is due to the more vigorous competition of the larger soldier fly larvae in the manure mass rather than to a direct predatory action. The larvae of *H. illucens* also keep the manure in constant motion, making it less attractive to house flies for oviposition.

PARASITES OF SPOTTED ALFALFA APHID

The cultures of three Braconid parasites of the spotted alfalfa aphid that were obtained from California in 1958 are still being maintained in the insectary at El Horno, and further releases were made in both the Valley of Mexico and the Bajío this spring. Two species have apparently become established in the Chapingo area, though further observations will be needed in early 1961 to confirm their establishment and determine their effectiveness.

CROP VARIETIES RESISTANT TO INSECTS

Entomologists from the section have continued to aid other sections in taking data on the resistance or tolerance of their breeding material to insect attack. At Cotaxtla, in cooperation with the corn section, weekly counts were taken of leafhopper populations, *D. maidis*, in three different planting dates of

76 lines and selections in an effort to correlate insect population with the incidence of corn stunt virus in this material. At CIANO, data were taken on the levels of infestation of rice stalk borer, *Chilo loftini* (Dyar), in three plantings of 28 varieties and crosses of rice. Distinct differences were noted in susceptibility of this material to borer attack. In a special planting of alfalfa at CIANO, observations were made on populations of spotted alfalfa aphid, *T. maculata*, in varieties selected in the United States for resistance and in Velluda Peruana, the most common variety in the area. The resistance of the varieties Moapa, Lahonton, and Cody was confirmed. Of these, Moapa and Cody are best adapted to the region, and although their total production was slightly less than that of V. Peruana, they can be recommended because they will produce more under aphid attack. Moapa is now being introduced into the Yaqui Valley from California.

In a preliminary laboratory study at El Horno in which ten different varieties of beans were subjected to equal infestation levels of the Bruchid, *S. pectorallis*, the three black varieties from the Gulf Coast region were less severely damaged than the light-colored Canario and Bayo types grown in the central valleys.

Miscellaneous Studies

The three-year study of corn seed storage under different conditions of relative humidity at Cotaxtla was terminated in January, 1960. Final results indicated the following: In a ventilated room without humidity control, seed maintained its viability for approximately six to eight months, when severe insect and fungus damage began. In the special chamber where the relative humidity was maintained at 50% without temperature control, germination was maintained above 85% for two and one half years, when viability decreased rapidly during the following six months to 50% or less. DDT applied to the seed at the time of storage at the rate of 50 parts per million lost its effectiveness after 18 months in the ventilated room but was still toxic to insects after three years in the controlled humidity chamber.

In a special test at Cotaxtla to determine the efficiency of storing commercial corn in sealed 50-gallon drums in the tropics, grain of the hybrid H-503 was stored without additional treatment at 13.5% moisture content in November, 1958. In a drum opened in March, 1960—16 months later—the corn was in good condition and free of insect attack. However, in a second drum, opened after eight months' storage in July, 1959, the corn had maintained its viability above 90%. This method of corn storage appears very practical for the small farmer in the Veracruz area, since seed can be maintained in good condition from harvest until the next planting, and corn for consumption can be maintained from one harvest to the next.

Multinucleated zoospores of *Phytophthora infestans.*

Plant Pathology

During the period covered by this report, special emphasis was given to research on head smut of corn and fungi of stored grains. In the initiation of the latter project, the plant pathology section was particularly fortunate in having the assistance of Dr. Clyde Christensen, from the University of Minnesota, who was assigned as a Special Temporary Scientific Aide. As in previous years, a considerable amount of work was devoted to the genetics of the late-blight fungus, *Phytophthora infestans.*

HEAD SMUT OF CORN

A survey in the Bajío area in August, 1959, revealed an incidence of from 0 to 5% of the disease, in general, and up to 30% in some fields near La Piedad, Michoacán. The causal agent, *Sphacelotheca reiliana* (Kühn) Clint., is a systemic fungus which replaces spikes and ears with a black mass of spores. The parasite can cause total grain loss on the plant, and is a potential threat to corn production in the Bajío area.

Research followed the same general lines as reported previously and experimental plots were located near Cortazar, Guanajuato. Under conditions of natural infection the hybrid H-353 was planted monthly from April to June, 1959. The highest incidence of diseased plants, 74%, was registered for the April plantings; the lowest, 3%, for those of June. This pattern was completely opposite to that observed in 1958. Such a reversal of trend in seasonal infection suggests that considerable basic information on the epidemiology of this fungus is lacking in Mexico. Work will be continued to provide a better understanding of this fungus and its relationship to ecological factors.

Nine fungicides recommended from previous trials, which have also given effective control in other parts of the world, were tested using the hybrid H-353 artificially inoculated with chlamydospores of *S. reiliana.* None of these fungicides provided significant protection; even the mercurial compounds which showed promise in 1958 tests failed to give any control of the fungus.

Local varieties and hybrids of corn recommended for the Bajío and for tropical zones were tested with artificial inoculations. The highest level of susceptibility was found in the tropical hybrid H–503 and the synthetic variety VS–550. The hybrids recommended for the Bajío showed a wide range of susceptibility; high for H–353 and significantly lower for H–220. A low incidence of the disease was observed in the local varieties Apaseo and Cortazar, percentages of infection being at about the 4% and 6% levels. Apparently resistance to head smut is present in local varieties and hybrids. If the incidence of the disease increases in the future, such material will be valuable as sources of resistance for breeding purposes.

WILT OF CHILE PEPPER

The project initiated in 1958 on wilt of the Chile pepper was continued, with studies directed toward a better understanding of the physiology of the causal fungus, *Phytophthora capsici*, and a search for sources of resistance in native pepper lines. Work conducted during the past season indicates that optimum growth of the fungus in four different media occurs at 28°C. Minimum growth occurs between 7° and 12°C., and maximum development is obtained above 35°C. No sporangia were formed in any medium or at any temperature.

In the study on the influence of carbon in artificial growth media for *Phytophthora capsici*, synthetic media containing arabinose, xylose, mannose, levulose, galactose, dextrose, maltose, sucrose, raffinose, and mannitol and a check without any carbon were observed. Best development of the fungus was obtained in a dextrose medium, although sucrose appeared to be assimilated faster. The growth in maltose was almost null at the beginning of incubation but suddenly resumed, perhaps because of the production of adapted enzymes capable of hydrolizing maltose. The influence of carbon in the production of sexual spores (oospores) was studied by mating two compatible cultures of the fungus. The formation of oospores did not occur in arabinose, xylose, galactose, raffinose, mannitol, or the check.

In a similar routine study, nitrogen compounds were tested to determine their effectiveness for the development of the fungus. Materials used included asparagine, urea, cystine, potassium nitrate, and ammonium sulphate. Best growth was obtained in the cultures containing asparagine; however, the development of the fungus in potassium nitrate was approximately 11 times more abundant than in ammonium sulphate. This observation may have some significance with regard to fertilization practices with the pepper.

Phytophthora capsici depends on Vitamin B_1 for normal development and apparently is not capable of synthesizing this material. At 0 level of Vitamin B_1 in the growth media, development was very poor. At 25, 50, and 100 mg. per liter levels, the fungus developed satisfactorily, with growth observed at the 25 mg./lit. level showing some superiority. The optimum pH for development of the fungus in these studies was 6.

At present, resistant varieties appear to be the best means of overcoming losses due to *P. capsici*. Forty-three collections of pepper lines, varieties, and species were inoculated with 35 strains of *P. capsici* in the greenhouse. Although none of the collections were completely resistant, nevertheless some plants showed resistance to a great number of cultures of the fungus. Maximum resistance was found in *Capsicum pendulum*, of Peruvian origin. The fact that the 35 strains of *P. capsici* utilized exhibited a wide range of pathogenicity suggests the presence of physiological races.

STUDIES ON PHYTOPHTHORA INFESTANS

It has been mentioned in previous reports that segregation of sexual types does occur in monozoosporic cultures derived from homothallic strains of *Phytophthora infestans*. In an effort to throw some light on this problem, a study was made of the nuclear condition of zoospores. With the aid of adequate staining methods, the numbers of nuclei were counted in zoospores obtained from cultures of *P. infestans* of sexual types A_1, A_2, and homothallic. The following results were obtained:

	No. zoospores with:		
Sexual type	1 nucleus	More than 1 nucleus	% with more than 1 nucleus
A_1	13,068	19,382	60
A_2	2,505	4,307	64
Homothallic	3,554	6,816	66

While these data do not explain segregations in single-spore cultures of *P. infestans*, they do indicate the need for more precise study of this material. Up to the present time, single-spore cultures have been considered as pure lines. However, in view of the high percentages of zoospores with more than one nucleus (see illustration, p. 80), the monozoosporic cultures should be studied carefully, since the nuclei contained in a zoospore can be different and therefore produce heterokaryotic mycelium.

Fungi of Stored Grains

Although research on the control of insects in stored grains has been conducted for many years by the OEE, the problem of damage caused by fungi had not been studied until last year. Annually thousands of tons of grain are lost in storage. It has recently become apparent that a considerable portion of this loss may be due to infection by fungi.

In an attempt to evaluate more precisely the damage caused by fungi, corn and barley samples were obtained in 1959 from storehouses in various parts of Mexico. For each sample the actual damage observable was estimated; in addition, a calculation was made of the potential damage in terms of grain moisture content and the quantity of spores of different species of *Aspergillus* and *Penicillium* present. A large quantity and variety of species of fungi were found in many samples entirely free of insects. In most cases the damage was to the seed embryos, which were attacked and totally destroyed. This information supports the hypothesis that insect damage is not necessarily associated with the presence of these destructive fungi.

Barley attacked by storage molds germinates poorly, with consequent decreases in yield and in the quality of the products derived from it. In Mexico considerable quantities of barley are stored soon after harvest with a relatively high moisture content. Under such conditions, extensive damage due to the fungi is to be expected. Samples taken from such stored barley were held in the laboratory for six months. Periodic tests revealed a rapid increase in the fungal population and a sharp drop in the germination percentage. At the end of the six-month period, the average germination of the samples was 30%.

Malting companies in Mexico are well aware of this problem and took the opportunity to send several technicians from their organizations to the laboratories at El Horno for training in the identification of fungi and interpretation of experimental results, and general training in routine procedures of damage evaluation.

Herbarium and Phytopathological Services

The permanent collection of diseased plants is made up at present of approximately 2,000 samples. Some interesting additions in the past year are listed below.

Pathogen	Host
Cercospora carotae	Carrot
Cercospora mangiferae	Mango
Colletotrichum pisi	Pea
Mycosphaerella pinodes	Pea
Mycosphaerella brassicola	Cabbage
Puccinia cyperi	*Cyperus* sp.
Puccinia oxalidis	*Oxalis* sp.
Puccinia purpurea	*Sorghum vulgare*
Psuedoplea trifolii	Clover
Septoria lactucae	Lettuce
Dothidella parryii	*Agave* sp.

Examples of diseased plants are frequently sent to the phytopathology section by extension agents and farmers. The laboratory provides identification of the samples and, when possible, offers suggestions for firm recommendations for the prevention and control of the pathogen. Below are listed some diagnoses made in 1959–1960.

Crop	Disease	Pathogen
Avocado	Leaf spot	*Cercospora purpurea*
Agave sp.	Leaf necrosis	*Coniothyrium* sp.
	Leaf spot	*Colletotrichum agaves*
Lettuce	Downy mildew	*Bremia lactucae*
Carrot	Rot	*Erwinia carotovora*
Pepper	Wilt	*Phytophthora capsici*
Onion	Purple spot	*Alternaria porri*
Tomato	Leaf blight	*Phytophthora infestans*
	Fruit blight	*Phytophthora* spp.
	Leaf spot	*Septoria lycopersici*

Weeds have a notable effect on corn growth. The plot on the right was kept completely weed-free from time of planting.

Herbicides

Low yields of the basic food crops are often directly attributable to weeds. Studies carried out at the Cotaxtla station on corn planted at the beginning of the rainy season, show that for each corn plant in the field there are from 2,500 to 5,000 seedlings of weeds present that will compete with the crop for water, light, and nutrients.

Farmers utilize the hoe, shovel, machete, and plow to eliminate these noxious plants, but the efficiency of such implements is low, as hand weeding is slow, tiresome, and costly. In order to remove weeds from 1 hectare of corn by these methods, as many as 15 days of labor are required. If herbicides are used, this operation need occupy only one day. At the present time herbicides, since they are relatively unknown to Mexican farmers, are not widely used in the culture of the basic food crops. Interest in these chemicals is increasing, however, and undoubtedly their inclusion in modern agriculture will contribute to greater national food crop production.

This report contains a brief account of several experiments carried out in corn fields at Cotaxtla during 1959, as well as of tests to explore the possibility of controlling "zarza" (*Mimosa pigra*) with herbicides.

Weed Control in Corn

EFFECT OF WEED TYPE ON CORN YIELDS

As weeds differ not only in growth habit but also in ability to compete with the cultivated crop, it is necessary to evaluate the damage produced by broad-leaf weeds, grasses, and natural mixtures of these two. At Cotaxtla the most important broad-leaf weeds are *Amaranthus* spp. and *Bidens* spp.; the predominant grasses are *Echinochloa colonum* (L.) Link, *Eleusine indica* (L.) Gaertn., and *Panicum* spp.

An experiment was conducted to measure the effect of the three weed types on yields of the corn variety H-503, fertilized with a 60-40-0 formula. Results showed that broad-leaf weeds offered the greatest competition to the corn plants. Plots infested with these weeds yielded only 1,114 kg./ha., whereas grass-infested plots yielded 3,750 kg./ha., and plots infested with a mixture of weed types yielded 3,233 kg./ha.

TIME OF WEED CULTIVATION

In an experiment to determine the period during the growing season when weed competition is most injurious, weeds were removed from plots of H–503 with hoe cultivation at different times. Results showed that corn yields were most affected by weed competition during the first 25 days after the corn was sown. Weed removal from the crop during the first 15 days was more beneficial than three or four weedings done after 25 days. This experiment also indicated that higher corn yields can be obtained if the fields are kept as free of weeds as possible during the first 30 days after planting.

EFFECT OF PLANTING METHOD ON WEEDS

In an effort to determine the effect of method of planting on the development of the corn crop, particularly with regard to soil moisture, studies were conducted in 1959 with machine- and hand-planted corn seed. Observations made in previous years had indicated that these two planting methods might have different effects on the moisture conditions of the soil and therefore on subsequent weed development, especially if a dry period occurred after planting.

Results obtained in 1959 show that there is no difference in corn yield due to planting method if weeds are eliminated. When weeds were not controlled, however, yields were approximately 600 kg./ha. less in the hand-sown plots than in those planted by machine. Weed control with herbicides was more effective in the hand-planted corn. The differences in weed growth and effectiveness of chemical herbicides were influenced by the seeding method used. When corn is planted by hand, with a forked stick, the top soil remains undisturbed and does not dry out; consequently, any weed seeds present germinate rapidly and the plants become well established before the corn seedlings. In contrast, planting machinery thoroughly mixes all the surface soil, and in the absence of rain this relatively shallow layer quickly dries; as a result, weed seeds present do not germinate and the corn seedlings thus have an opportunity to become sufficiently well established to compete favorably with the young weed plants.

COMPARISON OF FIVE HERBICIDES

During the 1959 rainy season, five herbicides at three different dosages were tested for weed control in corn. The materials used were: 2,4–D Amine, 2,4–D Ester, Dinitro Preemerge, Simazin, and Monurón. Check plots with three different levels of weed population were included. A split-plot design was used. Pre-emergence applications were made and no cultivation was practiced.

The highest actual yield of corn, 6.5 ton/ha., was obtained from the check plot kept free of weeds throughout the corn growing period. However, there was no significant difference between this yield and yields obtained from plots treated with 2,4-D Amine at dosages of 4, 5, and 6 liters/ha. Yields with all other treatments were significantly poorer. With each herbicide, the lowest dosage used was as effective as the higher dosages. While 2,4–D Amine was the most economical and effective

Effective control of "zarza" has been achieved by the use of herbicides.

herbicide in this study, past experience has shown that under conditions of excessive rainfall this herbicide causes damage to corn. The chemical Monurón gave the poorest weed control and damaged the corn plants.

BRUSH CONTROL

"Zarza" (*Mimosa pigra*) is a leguminous shrub that grows in low areas of the tropics. Attempts to eradicate this highly undesirable plant from grasslands by cutting with a machete or by burning have been unsuccessful in the Cotaxtla area over a period of 20 to 30 years.

In 1959, experiments for "zarza" control were begun using a mixture of 1 liter of Esterón 2,4,5-T per 100 liters of water. Applications were made 15, 30, 45, and 60 days following burning of the infested fields. The amount of herbicide mixture applied to the clumps of "zarza" varied in accordance with their size. In 1960, 12 months after treatment, data were taken on the effectiveness of the control measures. As shown in Table 1, the greatest plant mortality was obtained when the test chemical was applied 45 and 60 days following burning. More detailed tests are planned.

TABLE 1.

"Zarza" control with Esterón 2,4,5-T applied at different time intervals follo wing burning. Cotaxtla, 1959–1960.

Herbicide applications at:	No. of treated plants 1959	Sprout length at time of application	No. of dead plants 1960	Control
15 days after burning	209	2 to 15 cm.	138	66%
30 " "	222	5 to 30 cm.	175	79%
45 " "	208	40 to 60 cm.	199	96%
60 " "	164	80 cm.	161	98%
Check burnt without herbicide application	201		72	36%

All-palm poultry house at Cotaxtla.

Poultry

The poultry industry in Mexico has continued to show remarkable increases in number of hens producing eggs and in number of chicks raised for meat. The capacity of existing hatcheries has increased as well as the number of new installations dedicated to this activity. Greater diversification in the industry has also been observed. For example, one may find a considerable number of poultry farms which specialize in the production of fertile eggs for hatcheries, though for the most part parent stock is still imported chiefly from the United States. Broiler production has now become a specialized farm activity, and the number of farms producing table eggs has increased so that 10,000-bird flocks or larger are common.

The feed industry has found that its greatest volume of prepared feeds, over 90%, is destined for poultry consumption. Competition has resulted not only in better quality of products but also in more varied and specialized feeds. An increase has been noted in the volume of premixed concentrates, which are shipped widely throughout the country for use with local grain products.

The need for improved marketing and distribution techniques has prevented consumers from realizing greater benefits from the increased domestic production and availability of poultry products. Also, this past year, the poultryman faced his first real crisis in the marketing of his products.

Lack of statistics makes it difficult to analyze precisely the problems of the industry. The OEE has recently begun the compilation of monthly data on chick production in Mexico, based on monthly reports solicited from hatcherymen. For each of the first three months of operation, better than 70% of the records requested were received. If similar information can be obtained from other segments of the industry, a sound approach to their economic problems can be made.

POULTRY NUTRITION STUDIES

LAYING HENS

It has been known for some time that feed consumption in poultry is directly related to the dietary energy level. This fact suggested that the poor performance of chickens often observed during hot weather or in tropical climate was due to diminished total feed intake, with consequent ingestion of inadequate nutrient levels. Such a situation would be more pronounced in cases where marginal levels of critical nutrients are present, where high energy diets are used, and where levels of egg production and growth are being maintained. In an experiment conducted over a 24-week period with laying hens in cages and under floor management at Cotaxtla (tropical) and Santa Elena (subtropical), the importance of protein level was clearly shown. Three dietary protein levels were used, the protein component in each diet being identical except that the total amount per diet varied. Table 1 is a summary of egg production and feed consumption at the two stations. It will be noted that the 12% protein diet, which had also a higher energy level, was consumed in significantly lower quantities at Cotaxtla and resulted in lower egg production. At the energy level used, 15% protein, adequately balanced, is apparently sufficient to give a good level of egg production.

Certain feedstuffs are improved in nutritional value by heating (soybean) or by enzyme supplementation (barley). In an experiment with laying hens, it was found that neither autoclaving nor enzyme supplementation of Mexican corn improved egg production or feed efficiency.

Grain sorghums, or commonly milo, are often quoted at 60% to 75% of the price of corn in production areas. In spite of this differential in price, however, there is discrimination against milo by feed producers. Its equality with corn was again firmly established in an experiment involving approximately 1,000 laying hens over a 10-month period. Egg production, feed consumption, mortality, and egg quality characteristics were not different statistically when diets of equal composition except for the grain component were compared. In addition, there were no differences in these factors between cage and floor systems of management. The incorporation of milo in poultry feed should significantly reduce production costs.

In two experiments comparing the efficacy of garbanzo diets and corn-soy diets in maintaining high egg production, it was found that with either type of diet equally good production may be obtained in tropical and subtropical areas. Egg quality was equal in both types, but some slight advantage in body weight was observed in the hens fed garbanzo. The addition of tryptofan at 0.05% and 0.01% levels to several garbanzo diets did not improve egg production. The use of autoclaved garbanzo had a slight but not significant beneficial effect on egg production and did not improve feed efficiency.

CHICKS

In an experiment to determine the relative importance of protein quantity and protein quality in broiler growth, chicks were given an 18% or 21% protein diet up to nine weeks of age, or were switched from the 21% to the 18% diet after one, two, three weeks, etc., up to nine weeks. Results indicated no statistically significant differences in gain or feed

TABLE 1.

Effect of dietary protein level on egg production over a 24-week period.

Dietary protein level	COTAXTLA (*tropical*)						SANTA ELENA (*subtropical*)					
	18%		15%		12%		18%		15%		12%	
	C	F	C	F	C	F	C	F	C	F	C	F
% production	62.7	61.7	67.2	60.0	49.2	42.5	60.9	62.0	61.8	61.8	58.0	52.0
gm./day feed	104.0	97.3	105.5	97.2	91.4	80.6	111.1	104.8	118.0	110.2	105.9	101.4

C refers to cages; F to floor management.

conversion. If an adequate balance in amino acids is provided in the diet, chicks do well starting with 18% protein feed.

Prepared algae may have potential value in poultry diets. However, an experiment designed to test the effectiveness of algae as a replacement for dehydrated alfalfa indicated that while algae may be used in amounts up to 4.0% of the total diet without affecting growth and feed efficiency, no improvement resulted from its addition to a basal diet that did not include alfalfa meal or algae.

In a study of the energy-protein ratio in garbanzo diets, basal diets containing 72.70% garbanzo were adjusted to 20%, 22%, and 24% total protein; to these were added either fiber or fat to produce five different levels at each protein level. Under the resulting 15 dietary regimes it was found that growth improved as the energy level increased for both the 20% and 22% protein level diets. At the 24% protein level, however, additional energy was ineffective in increasing gains. The 20% protein diets were inferior to the others in feed conversion. High levels of garbanzo can be successfully incorporated in chick diets at no great sacrifice of feed-conversion efficiency provided the energy-protein ratio is correctly adjusted and other essential nutrients are adequate.

In an experiment designed to determine the effect of increasing the vitamin component of the diet in conjunction with increased levels of methionine and lysine, no response was observed in Leghorn male chicks. In broiler-type chicks, which have a faster growth rate, slight but distinct advantage (significant at the 0.05% level) was observed when the vitamin, lysine, and methionine components were increased above the basal level. It is apparent that, under certain experimental conditions, borderline deficiencies may go unnoticed. This is true in practice also. It becomes necessary now to pinpoint exactly the critical nutrients in the high-level garbanzo diets which limit maximum utilization by the chicks.

How vitamins may affect digestibility of garbanzo was explored in a basic nutrition experiment utilizing the chromic oxide technique. The basal diet in this experiment was as follows: garbanzo—95.800%, phosphate rock—2.120%, oyster shell—1.550%, salt—0.485%, and mineral mix—0.045%. Table 2 shows the effect of vitamin supplementation on digestibility and nitrogen retention of the garbanzo diets. In the same experiment, it was also shown that upon removal of each vitamin separately in the presence of all others, only the absence of Vitamin A reduced growth but the presence of Choline lowered feed efficiency.

In an experiment with a simplified diet in which the garbanzo comprised as much as 82% of the total, autoclaving improved significantly the growth of chicks to four weeks.

TABLE 2.

Effect of vitamin levels on digestibility and nitrogen retention of dietary dry matter.

Diet	Digestibility of dry material (%)	Nitrogen retention (mg./gm. dietary N)
Basal	36.40	2.3
Basal + Vitamin[a]	46.34	8.4
Basal + 2 × Vitamin	44.98	9.7

[a] Vitamins included per kg. of diet as follows: Vit. A; 4064 IU; Vit. D_8, 1200 ICU; Riboflavin, 3.29 mg.; Niacin, 30.99 mg.; d e calcium pantothenate, 24.65 mg.; Vit. B_{12}, .022 mg.; Choline chloride, 1.826 gm.; Penicillin, 10 mg.

INVESTIGATIONS WITH TURKEYS

Although the turkey is indigenous to Mexico and had been bred in domestication by the Indians for centuries before the discovery of America, there has been no investigational work done in Mexico with either the new commercial type of turkey, the criollo or native type, or the wild type. The research of the OEE on turkeys has three main objectives: (1) to study the feeding, management, and

Broad breasted hen, reared under special feeding regime, weighed 16.5 pounds at 21 weeks of age.

disease problems of the commercial turkey, (2) to investigate the economic and genetic potential of the native turkey, and (3) to initiate basic genetic investigation with the wild-type turkey, of which two varieties exist in their natural habitat.

The first year of experience with turkeys gave some insight into the kind of performance that might be expected and the general problems which merit investigation. Using three groups of 24 Broad Breasted White turkeys, equally divided by sex and weight, three different feeding regimes were studied. These were as follows: A—reared in confinement on complete diet plus chopped Ladino clover; B—same as A without forage; C—reared on pasture with free-choice concentrate and grain. The 21-week weights are shown in Table 3. From these data it is clear that the turkey will grow as well in Mexico as elsewhere and that considerable economy may be achieved through the use of forage crops.

POULTRY DISEASE LABORATORY

During 1959 the disease laboratory received an average of 39.2 cases monthly. Though the majority of cases originate in the State of México, the laboratory has received specimens from all over the Republic. Twelve new diseases were diagnosed in 1960 which previously had not come to the attention of the pathologists. Considerable time is spent by the laboratory staff in field visits because so many cases are complicated by faulty management, poor nutrition, and any number of factors that the poultryman fails to recognize as influencing the course of a disease.

TABLE 3.

Body weight at 21 weeks of Broad Breasted White turkeys grown under three dietary regimes.

	USA Standard Scott (1959)	Group		
		A	B	C
Av. weight (kg.)	7.928	8.096	7.742	7.806
Feed consumed (kg.)	28.267	24.884	27.133	24.009
Conversion	3.56	3.07	3.50	3.08
Feed costs/kg. (pesos)[a]	–	4.55	5.11	3.68

[a] Feed costs include cost of green forage in Group A and rent value of land in Group C.

Newcastle disease (pneumoencephalitis) appears to have made a major comeback in 1959. Not since the early 1950's have so many losses been attributed to this disease. The appearance of Newcastle in many flocks results in mortalities approaching 100%. Some virus isolates have caused 100% mortality of susceptible chicks when tested in the laboratory. In field outbreaks, many flocks previously vaccinated show "breaks" with high losses. In addition to actual mortality, a high percentage of survivors show central nervous system involvement.

The present research of the OEE is aimed at improving vaccination (protective) procedures so that an adequate immunity may develop which will protect chickens from natural infections. As a part of this research, all NDV isolates are being typed. Virulent strains will be tested in challenge tests with vaccine strains and in some cases with autogenous vaccines using killed virus.

Interviewing an *ejidatario.*

Agricultural Economics

The work in the agricultural economics section continues to emphasize investigation in the field of farm production economics. It is firmly believed that farming requires more capital and better management each succeeding year to take advantage of the rapidly expanding store of technical information. Studies which provide knowledge that will help those who have control over resources to use them more effectively, and which promote a better understanding of the realities of agricultural endeavor as an aid in developing more adequate agricultural policy, make a substantial contribution to the welfare of society.

Management and organizational problems are particularly severe under Mexican conditions because of the revolutionary changes in economic and social structure during the past 40 years. The agrarian reform programs carried out principally in the decades of the 1920's and 1930's formed the two present classes of farmers—the small proprietor and the *ejidatario.* The small proprietor has had the task of forming a rational farming operation either with a fraction of his previous holdings or out of lands with which he had not had previous experience. The increasing commercialization of agriculture confronts small proprietors with innumerable management problems in adopting optimal production procedures, of localizing production where it has greatest comparative advantage, and of producing in relation to market demand.

The *ejidatario* was also charged with the responsibility of organizing and managing a farming unit. His status automatically changed from that of quasi-feudalism to modern capitalism. The problems which this group of farmers face are dual. In the first place they usually lack the resources necessary for forming an efficient farming unit, and in the second they have not had the social preparation necessary to fulfill their responsibilities. Studies related to the economics of farm production for this group of farmers need to consider social and cultural factors which establish the parameters for economic and agronomic development.

ECONOMIC STUDY OF PRIVATELY OWNED FARMS IN THE YAQUI VALLEY, SONORA

The field work for this study was carried out during the winter 1958–1959. The Yaqui Valley was selected because it represents one of the developed areas of the Northwest, a region which has emerged as one of the most significant areas of agricultural production in the Republic. The data for the study were obtained by the farm-survey technique, and the information corresponded to the agricultural year, November 1, 1957, to October 31, 1958.

The objects of the study were:

(1) To describe the method and organization of agricultural production on the farms included in the sample, and to extend inferences to the agriculture of the region.

(2) To determine the production inputs for the several important crops as a basis for evaluating alternative cropping systems.

(3) To evaluate the influence of several agricultural practices on farm earnings.

(4) To estimate the productivity of several classes of farm investments in the agriculture of the region.

(5) To determine the cost and efficiency in the use of machinery and equipment.

An area-sampling procedure was utilized in which the Valley was divided into blocks of 1,600 hectares under private proprietorship. A 15% random sample of these blocks was taken and all farms that fell within the sample blocks were included in the study. A total of 85 complete farm records was obtained. Since area-sampling procedures give different probabilities for entering the sample to farms of different sizes, the farms were divided into four groups based on the number of hectares in the farm to help give an idea of typical units of exploitation in the area. The four size groups were: small, from 0 to 39.9 hectares; medium, from 40.0 to 139.9 hectares; large, from 140.0 to 339.9 hectares; and very large, 340.0 and more hectares.

Table 1 gives a brief description of the farms studied in terms of land available, labor employed, capital invested, operator's labor income, and rate earned on capital. The small farms were not large enough to support the full complement of capital associated with a satisfactory farm business under commercial agricultural conditions. The three groups of larger farms did have relatively complete capital structure.

Cotton and wheat are the two most important crops in the region. Corn is growing in importance, however; in fact, it was possible to see a considerable increase in the area planted to corn between the 1957 and 1958 growing cycles. Yields for all crops were comparable among the different size groups of farms.

It may be noted in Table 1 that both operator's labor income and rate earned on capital (including value of land) are positively correlated with scale of operation. The fact that both farmer's labor income and rate earned on investment are correlated suggests that there may be real efficiencies to scale in the area studied. There is perhaps a more powerful tool for evaluating resource combination efficiency than the simple residual measures. This is the construction of a pro-

TABLE 1.

Descriptive characteristics of 85 farms studied in the Yaqui Valley, 1957–1958.

Item	Small	Medium	Large	Very large
Area in the farm (hectares)	23	87	211	466
Labor employed (months)	32	86	181	365
Farm investment, excluding value of land (pesos)	25,700	174,200	404,600	1,143,000
Farmer's labor income (pesos)	3,100	5,500	53,800	232,400
Rate earned on investment, including value of land	6%	9%	14%	18%

duction equation which can be evaluated to estimate returns to scale and relative marginal productivities.

The farm data obtained from this study were used to calculate a production equation of the type Cobb-Douglas, which is to say, straight line in the logarithms. In this equation, production is considered a function of the input of land, labor, power and machinery, crop services, and livestock services. The equation statistically fitted by the method of least squares is:

$$P = 170.4\, L^{0.588}\ M^{0.047}\ C_m^{0.004}\ C_c^{0.398}\ C_l^{0.004}$$

where P is the total value of crop and livestock production, L is the number of hectares cultivated, M is the labor employed in months, C_m is the machinery and equipment input in pesos, C_c is the capital input of crop services in pesos, and C_l is the capital input of livestock services in pesos.

This equation is of a particularly convenient form in that it lends itself well to economic analysis. The exponents are the regression coefficients for the equation in logarithmic form; they are the elasticities of production for the function, that is, they indicate the percentage increase in product for each 1% increase in input of the respective resource. The sum of the exponents indicates the percentage by which the total value of product increases as all factors (land, labor, and capital) are increased by 1%. When the sum of the exponents equals 1.0, constant returns to scale hold true; a 1% increase in input results in a 1% increase in output. If the sum of the exponents is less than 1.0, diminishing returns to scale hold true, and a 1% increase in input results in less than a 1% increase in output. A sum greater than 1.0 indicates increasing returns to scale and increasing resource efficiency.

The production function may also be used to estimate the marginal productivity of a given resource by taking the partial derivative of the dependent variable with respect to this resource. The marginal productivity of a factor is the increase in value of output for each one-unit change in the given factor, with other factors held constant.

The sum of the exponents in the derived equation for private proprietorship in the Yaqui Valley is 1.04. This suggests that there are economies of scale in the agriculture of the Valley. In consequence, it is possible to conclude that larger exploitations are economically more efficient than small operations. This may be due to two factors. One, the larger operators may have developed proportionately better management skills and be able to combine their production resources in more remunerative businesses; or two, the type of mechanization may require extremely large areas to gain its economic advantage. This is an area of large track tractors and their complementary implements. Perhaps in following the mechanization pattern of the large holders the smaller operators have placed themselves at a disadvantage. The efficiency in larger scale units discussed here is consistent with the residual income measures presented in Table 1.

Evaluation of resource efficiency for a particular agricultural region can best be made in terms of the marginal productivities of the resources at their typical levels of use. The marginal productivities of the several resources evaluated at their arithmetic means for the agriculture in the private sector of the Yaqui Valley are given in Table 2.

The marginal productivities of the several resources must be interpreted in terms of the cost of the resource. For example, the rental charge for a hectare of land in the Valley is approximately \$600 per year and the cost of a man-month of labor is about \$500. It will be readily seen that each peso spent on renting an additional hectare of land will return approximately three times its cost. An additional month of labor, on the other hand, would cost about \$500 and would return only about one-third of its cost. In similar manner it may be seen that the marginal peso spent on machinery and equipment returns only 2 centavos and is therefore almost completely lost. Almost the same is true of the marginal expenditure on livestock services. In contrast, crop

TABLE 2.

Marginal productivity of classes of inputs at their arithmetic means, when other inputs are at their mean values. Yaqui Valley, 1957–1958.

Input	Marginal productivity
Land (hectares)	$1,817.00
Labor (man-months)	167.00
Machinery and equipment (peso expenditure)	0.02
Crop services (peso expenditure)	1.57
Livestock services (peso expenditure)	0.07

services return $1.57 for each peso spent at the margin.

In general, what do these data on marginal productivity indicate about the agriculture under study? They clearly indicate a substantial disequilibrium in the combination of the agricultural resources in the Valley. Here, as has been previously observed in other parts of the country, farmers have not utilized their machinery efficiently, most particularly in the sense of reducing their labor inputs. This becomes clear when the low productivities for both machinery and labor are contrasted with the high productivity of land. In the Valley, farmers also often have more machinery and equipment than is justified by the amount of work to be done. There is sufficient labor and machinery available to work additional hectares of land without increasing the labor and capital inputs; hence, the high productivity of the marginal hectare of land. This may be illustrated in still another manner. Data were obtained on tractor costs and utilization for the Valley. A group of small tractors that were used on the average 293 hours in the course of a year had an average total cost of operation of $23.97 per hour; however, tractors that averaged 793 hours had average hourly costs of operation of $12.39, and those that averaged 1,155 hours had average hourly costs of $9.62. Similar relationships exist between use and costs for the other classes of machinery and equipment on farms. Changes in the organization or management of farms which will increase the utilization of machinery and equipment will aid materially in improving resource efficiency.

The Valley is principally a crop-farming area, and the low productivity of livestock enterprises is clearly a case of poor management. The enterprises are typically small and considered of little importance by farmers. Two poultry enterprises included in the sample were exceptions to this generalization.

The data presented indicate there are substantial opportunities for increasing resource efficiency in this region. As this project continues, alternative farming systems are being evaluated by calculating budgets for different rotations based on the data already obtained. These alternatives should indicate a more nearly equal marginal productivity per peso spent on each of the resource categories—this being an approximation to economic optimum allocation.

OTHER STUDIES IN PROGRESS

An economic study of *ejidal* agriculture in the Yaqui Valley.

A socio-economic study of three *ejidos* in the Valley of Mexico.

A socio-economic study of selected *ejidos* in the Comarca Lagunera.

An exploratory study of a regional market for agricultural products; Tehuacán, Puebla.

Results of demonstration plantings play an important part in introducing improved agricultural practices.

Agricultural Information

Over the years, the OEE research program has developed new varieties and hybrids of several crops and has tested many ideas which have resulted in recommendations for improved practices by which Mexican farmers can increase their total production and production efficiency.

The function of the information section is to translate research results into terms which extension agents can use with farmers. Following are some of the activities of this section during the past year.

PUBLICATIONS

RESEARCH REPORTS

Three publications appeared in the *Folleto Técnico* series and one in the *Folleto Misceláneo* series during the year.

Agricultura Técnica en México continued to supply Mexican agronomists with an up-to-date report of advances in the field of agricultural research. This semi-annual magazine, initiated by the Director General of Agriculture, has been strongly supported by the OEE from the beginning and during the past year published some 39 articles by OEE authors. It has now been made an official publication of the Ministry of Agriculture. Agronomists and libraries in some 45 countries receive these reports.

BULLETINS FOR FARMERS

The popular publications program of the Extension Service received strong support from the Director General for Agriculture during the year. The offset shop is now printing large quantities of some of the most popular bulletins, thereby giving Extension agents informational assistance which they value very highly. More than 170,000 copies of the Extension bulletins in which OEE authors have participated, were distributed by the publications department of the Director General's office last year.

In the quarterly *Novedades Hortícolas* series, 11 articles appeared with information for growers of horticultural crops.

As the regional experimental centers have grown, the information section of the OEE has helped to write and edit publications for them. Ten new publications and six revisions were printed during the year. An effort has been made to employ the terms and vocabulary most clearly understood in each region.

Two special reports were edited and published: a four-year report of the work of the

CIANO station, and the proceedings of the fifth annual meeting of the Central American Corn Improvement Program.

A complete list of OEE publications for the past year is given at the end of this report.

COOPERATION WITH OTHER MEDIA

With the growing use of new technology in Mexican agriculture, many of the commercial firms selling agricultural products are increasing their advertising expenditures. This in turn provides support for new farm pages in daily newspapers and for the creation of new farm magazines and new farm radio and television programs. Although information and photographs are provided when requested, the OEE has set up no special facilities to make use of these outlets, preferring instead to provide information through the federal Extension Service.

Bulletins in the Extension series and circulars in the regional centers' series have been used extensively by these other media. Many times they are reprinted in full. For example, during the past year the principal farm magazines carried more than 100 articles reprinted from or based on publications which originated in the OEE. Among these, *El Campo* published 19, *Tierra* published 16, *Gaceta Agrícola* 14, *Cosecha* 12, and *México Agrícola* 9. Several daily newspapers also made extensive use of OEE publications for their farm pages, the most notable being the nationally circulated daily, *Novedades*.

AGRICULTURAL FILMS

The educational film program has attracted interest among both government and private organizations working in the field of agricultural extension and development. Many organizations have borrowed prints of these films and several have later purchased their own copies in order to have them continuously available.

PRODUCTION

Three additional titles were added during the year, bringing the number of films produced in this cooperative project (OEE and Extension Service) to a total of 13. The new titles are:

"*Camote, La Raíz de Oro*" (Sweet Potato, The Root of Gold), which describes two improved varieties and better cultural practices;

"*La Ciencia Agrícola Impulsa al Noroeste*" (Agricultural Research Stimulates the Northwest), which describes what the CIANO center is doing to solve some of the principal agricultural problems of this important area; and

"*Alfalfa, Su Manejo y Utilización*" (Management and Utilization of Alfalfa), which continues the story of a previous movie on establishing a good stand of alfalfa.

DISTRIBUTION

Exhibitions were carried out in at least 20 of Mexico's 29 states, and in 10 other countries. More than 140,000 persons are known to have attended exhibitions of one or more of these films in Mexico alone during the past year. No record of projections is available for the 25 prints which have been purchased by organizations in El Salvador, Venezuela, and Colombia or for those purchased by private groups in Mexico.

These movies are intended to provide general principles and to inspire farmers to want to accept new practices; once the farmer is receptive to a particular change, he may obtain details through bulletins, talks with agronomists, etc. Bulletins with detailed recommendations are available on most of the subjects which have been treated pictorially in movies. In the case of corn, three bulletins with recommendations for specific regions serve as a complement to the movie "*Abone Su Maíz y Coseche Más*," which was used extensively during the past year in a corn production campaign.

The federal Extension Service now has 10 mobile units and the film library, which was started in the OEE, has been turned over to this agency.

AGRICULTURAL FAIRS

In addition to lending material to extension agents for use at several fairs, the information section participated directly in preparing exhibits for heavily attended expositions at San Luis Potosí, S.L.P., Cuatro Caminos, México, Celaya, Guanajuato, Veracruz, Ver., Villahermosa, Tabasco, and Tres Valles, Veracruz. In each case an agronomist was available to answer questions and give additional explanations of the information presented.

FIELD DAYS

Although visitors are always welcome at the experimental centers, a special day is set aside once or twice a year at each of the stations when all of the farmers of the region are invited to come to the station and see the work under way, ask questions, and discuss their own experiences. On this day the research workers explain their research and the results they have obtained. Extension workers are generally in charge of inviting the farmers and organizing them into groups for viewing the experimental work. Upon arriving at the station, farmers are registered so that they may be invited by circular letter to subsequent events, and then they are dispatched in groups of 50 to 75 for the tour of the experimental plots. In moderate sized groups of this nature, each person is able to see the material being demonstrated and ask any questions that he may have.

During the period covered by this report two field days were held at Cotaxtla and one each at CIANO and El Horno with a total attendance of nearly 5,000 persons.

In each case there was a considerable increase in attendance over previous years, perhaps as a result of: (1) the increasing prestige of the research centers, and (2) better planning of the publicity based on the results of information collected from those attending previous events.

The results of experimentation at a given

Field day at Cotaxtla, April 29, 1960. More than 1,700 persons arrived by bus, car, truck, and on foot.

SECRETARIA DE AGRICULTURA Y GANADERIA
OFICINA DE ESTUDIOS ESPECIALES
Centro de Investigacion Agricola
y de Industria Animal
para Zonas Tropicales
CAMPO COTAXTLA VER.

center may have application over a wide area, but the number of farmers who can be reached through experiment station field days is limited in part by the physical problem of distance. Nevertheless, the CIANO field day (State of Sonora) drew 10% of its participants from as far away as Sinaloa and interested individuals from such distant points as the States of Baja California, Veracruz, Tlaxcala, Chihuahua, Jalisco, México, and Michoacán, as well as from Mississippi and Arizona in the United States. The Cotaxtla field days, while drawing some 80% of their participants from many areas of the State of Veracruz, also drew numerous visitors from Oaxaca, Puebla, Tabasco, and Chiapas. The El Horno field day drew 75% of its attendance from the State of México and the Federal District. Many participants also came from the States of Puebla, Tlaxcala, and Hidalgo, and a small number came from points as far distant as Veracruz, Michoacán, Zacatecas, and Querétaro.

Approximately three fourths of those attending were farmers and ranchers, but an important group of agronomists, students, and teachers also participated. At CIANO agronomists accounted for 20% of the attendance, a reflection not only of the number of agronomists working in this rapidly developing region, but also of the high prestige which CIANO enjoys among this group of key men in agricultural development.

Not only private owners, but also a large number of *ejidatarios* attended each of the field days—an encouraging fact in view of the difficulty of reaching this second group with most of the media available to an extension worker. *Ejidatarios* accounted for approximately 59% of the attendance at each of the Cotaxtla field days, for 25% at CIANO, and for 39% at El Horno.

In the Northwest the agriculture is considerably mechanized, but in the Gulf tropics and the central plateau mechanization is not so prevalent. In order to have a clearer idea of the types of farmers being reached and the kind of practices which can be recommended, the following data were obtained from those who operate farm land:

Source of power[a]	EL HORNO Sept., 1959	COTAXTLA Sept., 1959	COTAXTLA April, 1960
Hand labor	0.6%	12.1%	16.7%
Animals	66.9	77.0	66.6
Tractor	32.5	10.9	16.7
	100.0%	100.0%	100.0%

[a] In the compilation of these data, farmers using both tractor and animals were listed only in the group with tractor; those using both animals and hand labor were listed only in the group employing animals.

The implications of these data are clear. At El Horno, one third of the farmers attending the field day can make use of recommendations requiring the use of the tractor; the other two thirds cannot. At Cotaxtla, less than one fifth of the farmers attending can count on a tractor; those who work by hand outnumber those who have tractors.

DIFFUSION OF INFORMATION FROM THE REGIONAL CENTERS

In order to make research results available more quickly and completely to farmers of the region, a pilot extension program has been established at Cotaxtla by the OEE and the Extension Service. During the past two years, the OEE has had a full-time agronomist in charge of diffusion of research results at Cotaxtla and this man is now also the federal Extension representative for the State. In this way, agricultural research and extension are closely coordinated at the regional level, with benefits to both programs. In addition to diffusing knowledge of improved practices which have come out of the research program, the extension personnel call the attention of research workers to important agricultural problems which they encounter in the region. This program is also occupying an important role in the training of new personnel in extension methods as well as in subject matter fields. The field experience obtained can serve as a basis for developing improved extension programs in other areas.

Although it may not be necessary to have regional research and extension personnel headquartered at the same place, it appears that proximity has been an important reason for success at Cotaxtla. The daily contact between extension and research workers, their close cooperation in handling farmers' requests for information, and their weekly exchange of ideas at Cotaxtla seminars, all contribute to a feeling of mutual respect and cooperation.

A well-rounded extension program has been carried out, including seed distribution, field days at Cotaxtla, and numerous result demonstrations in the surrounding areas.

Twenty-six demonstrations comparing the OEE hybrid H–503 with local corn varieties were planted in the central and southern parts of the State of Veracruz along with seven rice demonstrations and ten of sesame. Other demonstration plots were planted in cooperation with the State of Tabasco, the Papaloapan Commission, and Irrigation District No. 65 of the Secretariat of Water Resources.

These lots were established cooperatively with *ejidatarios* and private farmers and in some cases with the parents' associations, which operate the rural school parcels. Cotaxtla provided the seed and other demonstration materials, while the farmers provided the land, prepared it, and looked after the cultivation and harvesting of the crop. Many neighbors helped out at harvest time and were present for weighing the yield of several rows of each variety. In this way, they confirmed for themselves the advantages of the new practices.

Observations of these plots and the yield data are providing research workers with a more complete picture of the region of adaptation for new hybrids, while extension workers obtain a sounder basis for making future recommendations. In several cases the simple change from a local variety to H–503 gave as much as a 50% increase in yield.

A weekly farm page in the principal daily newspaper of the region continues to be another of the important outlets for Cotaxtla results. The newspaper provides the space while research and extension personnel at Cotaxtla provide the information. Some 1,800 farmers and livestock growers see this page every week. Many of them later come to Cotaxtla for personal consultation and to obtain seeds or vegetative material.

Results are also given out through agricultural fairs, regional bulletins, and educational movies made by the OEE-Extension film team.

The central area of Veracruz has been studied to determine the extent of ownership of radio receivers among farmers and the hours when they are accustomed to listen. As there is a great deal of interest among radio stations and among commercial firms who wish to sponsor a farm radio program, as well as among farmers and ranchers who have receivers, a program will soon be started.

Four youth clubs were organized during the year at Los Naranjos, Rodríguez Tejeda, Jamapa, and El Mangal, all in the central part of the State of Veracruz.

Much of the success of this pilot program is a result of close cooperation with many other organizations working toward agricultural improvement and development in the Gulf tropics. The extension workers at Cotaxtla have made a special effort to establish and maintain close relations with all other groups working toward similar goals. In this way the efforts of a small number of extension agronomists have in effect been multiplied.

The Library

The Library of the OEE operates as an integral part of the agricultural research program. While it makes a special effort to serve staff members and their assistants, the Library is also open to local professionals and to professors and students of different schools of higher education. In order to fulfill its objectives, the Library provides (1) scientific materials for research, (2) teaching materials to be used in the Graduate School of the National School of Agriculture at Chapingo, the National University, and the several other schools of agriculture in Mexico, (3) bibliographic information concerning the different fields of agriculture and related fields, and (4) technical knowledge of librarianship to Mexican and other Latin American libraries.

The Collection

On April 15, 1960, the Library stacks contained 9,143 bound volumes, of which 4,635 represent reference books, textbooks, and monographs and 4,508 are journals. The Library has 24,078 publications from the U. S. Department of Agriculture and different agricultural experimental stations in the United States. Geographic materials such as maps and atlases have reached a total of 946. As regards reprints, 14,302 have been catalogued. The Library is receiving by subscription 210 scientific serials specializing in plant and animal science and related fields. This modern library is the only one of its kind in the country and stands out as one of the finest in the agricultural sciences in Latin America.

The following statistics are available concerning use of the Library during the past year:

Books checked out	473
Books used in the Library	917
Periodicals checked out	239
Periodicals used in the Library	1,306
Reprints checked out	58
Reprints used in the Library	461
Miscellaneous publications checked out	126
Miscellaneous publications used in the Library	701
Consultations	216
Attendance	3,666

Reference Service

For the benefit of the research staff, the Library maintains an excellent interlibrary loan service with the most important libraries located in Mexico City, such as the Center of Scientific and Technical Documentation of Mexico, the National Commission for

Nuclear Energy, the different departmental libraries of the National University, the Benjamin Franklin Library, the Library of Mexico, and the libraries of the Bank of Mexico, the *Nacional Financiera*, and the National Institute of Cardiology. It is planned to extend this loan service to other local and American institutions.

The Library makes every effort to provide all kinds of bibliographies for staff members and for foreign individuals and institutions. Through its photoduplication service the Library has been acquiring materials such as microfilms, microcards, and photocopies of scientific works that it does not have or that are not available in Mexico.

LIBRARY TRAINING

Since there are very few professional librarians in Mexico, the Library has been training personnel for the posts at the Cotaxtla and CIANO stations. These are two young, developing libraries that are supporting scientific research among the young Mexican agronomists working at the stations.

Colombian Agricultural Program

Personnel

COLOMBIAN AGRICULTURAL PROGRAM

MINISTRY OF AGRICULTURE

His Excellency, **Dr. Gilberto Arango Londoño,** Minister of Agriculture
Orlando Fals Borda, PH.D., Director General
Nacianceno Osorio Betancourt, Secretary General
Régulo Perdomo, ING. AGR., Technical Secretary
Aníbal Duque Vélez, Administrative Secretary

DEPARTMENT OF AGRICULTURAL RESEARCH (DEPARTAMENTO DE INVESTIGACION AGROPECUARIA—"DIA")

Canuto Cardona Alvarez, PH.D., Director
Daniel Mesa Bernal, ING. AGR., Subdirector
Emigdio Pinzón Martínez, VETERINARIAN, Subdirector
Jacinto López Herrera, ING. AGR., Assistant, Planning Office
Milciades Martínez Gustín, VETERINARIAN, Head, Publications Office
Roberto Torres Restrepo, ING. AGR., Head, Climatology (Section transferred to Instituto Geográfico Agustín Codazzi, February, 1960)
Enrique Trujillo Medrano, Administrator

EXPERIMENT STATIONS

Pedro María Contreras Castillo, VETERINARIAN, Director, Armero Station
Ramón Murgueitio Posso, ING. AGR., Director, Tibaitatá Station (until February, 1960)
Jorge E. Ramón, ING. AGR., Acting Director, Tibaitatá Station
José Miguel Cortés L., ING. AGR., Director, Surbatá Station, Bonza (until January, 1960)
Francisco Handszer, ING. AGR., Acting Director, Surbatá Station, Bonza
Orlando Sánchez Emers, ING. AGR., Director, Nataima Station, El Espinal
Jorge Meza Nuncira, VETERINARIAN, Director, El Nus Station
Ernesto Arango Uribe, ING. AGR., Director, Tulio Ospina Station, Medellín
Bernardo Salazar Ramírez, VETERINARIAN, Director, Montería Station and Turipaná Station, Cereté
Jaime Medina Perdomo, ING. AGR., Director, Obonuco Station, Pasto
Enrique Llano Gómez, ING. AGR., Director, Palmira Station

Guillermo Villar Cuellar, VETERINARIAN, Director, San Julián Station, Pitalito (Station transferred to Department of Huila, March, 1960)
José Joaquín Cortés C., VETERINARIAN, Director, San Jorge Station, Soacha
Reynaldo Rubio Ramírez, VETERINARIAN, Director, Toluviejo Station
Alfredo Usme Romero, VETERINARIAN, Director, La Libertad Station, Villavicencio

OFFICE OF SPECIAL RESEARCH
(OFICINA DE INVESTIGACIONES ESPECIALES—"OIE")

U. J. Grant, PH.D., Director OIE, The Rockefeller Foundation

CORN IMPROVEMENT

David H. Timothy, PH.D., Technical Director, Associate Geneticist, The Rockefeller Foundation
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Manuel Torregroza Castro, M.S., Geneticist, Head, Corn Section, Tibaitatá
Bertulfo Peña Velásquez, ING. AGR., Geneticist, Head, Corn Section, Tulio Ospina, Medellín
Efraín Díaz Botero, ING. AGR., Geneticist, Head, Corn Section, Palmira (on study leave)
Clímaco Cassalett Dávila, M.S., Geneticist, Head, Corn Section, Montería
Daniel Varela Almanza, ING. AGR., Geneticist, Tibaitatá
Daniel Sarría Villano, ING. AGR., Geneticist, Acting Head, Corn Section, Palmira
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Fernando Arboleda Rivera, ING. AGR., Geneticist, Palmira
Ariel Gil Benavides, ING. AGR., Auxiliary Geneticist, Tulio Ospina, Medellín (until June, 1959)
Javier Gómez Jaramillo, ING. AGR., Geneticist, Tulio Ospina, Medellín

WHEAT IMPROVEMENT

John W. Gibler, PH.D., Technical Director, Plant Pathologist, The Rockefeller Foundation
Charles F. Krull, PH.D., Assistant Geneticist, The Rockefeller Foundation
Mario Zapata Balcázar, M.S., Subdirector, Tibaitatá
Hernando Reaga Santos, ING. AGR., Farinologist, Milling and Baking Laboratory, Tibaitatá
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Reinaldo Reyes N., ING. AGR., Geneticist, Head, Wheat Section, Tibaitatá
Luis A. Rojas, ING. AGR., Auxiliary Geneticist, Tibaitatá
Antonio Miranda H., ING. AGR., Auxiliary Geneticist, Tibaitatá

BARLEY AND OAT IMPROVEMENT

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Santiago Fonseca M., B.S., Auxiliary Geneticist, Tibaitatá

José A. Estévez C., ING. AGR., Auxiliary Geneticist, Tibaitatá

Leonidas Angarita B., ING. AGR., Auxiliary Geneticist, Tibaitatá (until April, 1960)

Carlos de la Fuente, ING. AGR., Auxiliary Geneticist, Tibaitatá (until February, 1960)

RICE IMPROVEMENT

Peter R. Jennings, PH.D., Technical Director, Associate Geneticist, The Rockefeller Foundation

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Joaquín González F., ING. AGR., Auxiliary Geneticist, Palmira

Idinael López M., ING. AGR., Auxiliary Geneticist, Palmira

Oscar Sohm K., ING. AGR., Geneticist, Head, Rice Section, Nataima, El Espinal

POTATO IMPROVEMENT

Lee E. Heidrick, M.S., Technical Director, Associate Plant Pathologist, The Rockefeller Foundation

Nelson Estrada Ramos, M.S., Geneticist, Head, Potato Section, Tibaitatá

Lauro Luján Claure, ING. AGR., Auxiliary Geneticist, Tibaitatá

Edmundo Pérez Montenegro, ING. AGR., Auxiliary Geneticist, Tibaitatá (until December, 1959)

Luis A. Varón, ING. AGR., Auxiliary Geneticist, Tibaitatá (assigned to Popayán)

Carlos E. Rangel, ING. AGR., Auxiliary Geneticist, Obonuco, Pasto

Lazlo Tüdös de Varffy, ING. AGR., Auxiliary Geneticist, Tibaitatá

FORAGE AND PASTURE CROPS

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Jaime Lotero C., M.S., Auxiliary Agronomist, Tulio Ospina, Medellín

Alfonso Bastidas R., ING. AGR., Auxiliary Agronomist, Palmira (on study leave)

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Hernán Chaverra G., ING. AGR., Auxiliary Agronomist, Tibaitatá

José Vicente Silva, ING. AGR., Auxiliary Agronomist, Palmira

Guillermo Riveros R., ING. AGR., Auxiliary Agronomist, Tibaitatá

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SOIL SCIENCE

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Luis Alfredo León S., CHEMIST, Soil Laboratory, Palmira
Alejandro Hugo Manzano, ING. AGR., Auxiliary Soil Scientist, in charge, Soil Section, Obonuco, Pasto
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ENTOMOLOGY

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ANIMAL SCIENCE

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Camilo Duque G., B.S., Auxiliary Animal Husbandman, Tibaitatá
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Oscar Cardona A., VETERINARIAN, Auxiliary Animal Husbandman, Montería
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VETERINARY SCIENCE

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Luis Carlos Wiedemann, VETERINARIAN, Animal Pathologist, Palmira
Hernán López Rubio, VETERINARIAN, Auxiliary Animal Pathologist, Toluviejo
Guillermo Mateus V., VETERINARIAN, Auxiliary Animal Pathologist, El Nus
Hernán Zaraza O., VETERINARIAN, Auxiliary Animal Pathologist, Montería
Casimiro Molina S., VETERINARIAN, Auxiliary Animal Pathologist, Armero
Otto Sánchez F., VETERINARIAN, Auxiliary Animal Pathologist, San Jorge, Soacha
Gustavo Rave Valencia, VETERINARIAN, Auxiliary Animal Pathologist, La Libertad, Villavicencio
José Omar Hincapié, VETERINARIAN, Auxiliary Animal Pathologist, Animal Science Laboratory, Tibaitatá

BIOMETRY

William H. Hatheway, PH.D., Technical Director, Assistant Statistician, The Rockefeller Foundation
Pedro R. Oñoro, ING. AGR., Auxiliary Biometrician, Tibaitatá
Luis E. Castiblanco, ING. AGR., Auxiliary Biometrician, Tibaitatá

FARM ADMINISTRATION

Roland E. Harwood, B.S., Technical Director, Associate, Experiment Station Operations, The Rockefeller Foundation
Jorge Quintero, ING. CIVIL, Head of Engineering, Tibaitatá
Horacio Ochoa, ING. AGR., Farm Administrator, Palmira
Jorge Fonseca, ING. AGR., Farm Administrator, Tibaitatá (until January, 1960)
Jorge León Suescum, ING. AGR., Farm Administrator, Tibaitatá
Luis Ortegón, ING. AGR., Auxiliary Engineer, Tibaitatá (until October, 1959)
Marco T. Arellano, ING. CIVIL, Auxiliary Engineer, Tibaitatá

Director's Introduction

The Colombian Agricultural Program was established in May, 1950, by agreement with the Colombian Ministry of Agriculture. The objective was to develop cooperative research between the Ministry and the Foundation on basic food crops of the country. The program began under the name "Office of Special Investigations" (OIE) and this office still exists, although it is now a part of the Department of Agricultural Research (DIA) which was subsequently created. DIA was created to integrate all plant and animal research under one department in the Ministry of Agriculture. In creating DIA much care was taken to see that it was provided with sufficient autonomy that the experimental work could be carried out without undue administrative difficulties.

Corn, wheat, beans, and potatoes were considered to be the basic food crops which should be given first priority in the improvement programs. Research work on corn and wheat was initiated at the beginning of the program, and by the fall of 1952 work on beans and potatoes was under way.

It was soon realized that some of the main problems encountered in producing crops in Colombia were the control of diseases and insects and soil management, including drainage and irrigation; an entomologist, a soil scientist, and a pathologist were therefore added to the staff in 1952.

After requests from the Ministry of Agriculture, barley was also added to the list of crops for improvement. The local brewing companies have cooperated and helped financially and otherwise to make this improvement program successful.

Shortly before DIA was organized, land for the National Center now called Tibaitatá was purchased. A farm manager was added to the staff to help with the development of this and other experiment stations operated by DIA. This staff member was not only charged with the responsibility of developing the experiment stations but he was also responsible for training farm administrators to take over the work as rapidly as possible. The same is true for each of the staff who has as his major objective the training of Colombian personnel to take charge of the various improvement programs as rapidly as they can do so.

In 1955 it was decided that the Colombian program would add the animal sciences and in conjunction with these programs a forage crops specialist was also added. The first animal scientist joined the program in March, 1955, to head the meat animal programs. Since that time a dairy scientist and a veterinarian have begun their work in Colombia.

The last two sections to be added to the Colombian Agricultural Program were rice and statistics. A rice improvement program was very necessary, particularly because of a virus disease of rice called "hoja blanca." This disease is a limiting factor of production in some years, especially in the Cauca Valley, an important agricultural region in the country. The attempt to transfer resistance to the disease, which is found in certain rice varieties with short grain, to the more desirable long-grain varieties has been highly successful.

DIA is an unique organization in Colombia in that while it is a department administered by personnel of DIA, its fiscal control is handled by an agricultural bank called the Caja de Crédito Agrario, Industrial y Minero. The Caja Agraria also furnishes DIA with the services of visiting auditors who check inventories and storeroom records at the various experiment stations. This service has proven exceptionally useful since DIA can depend upon rapid and efficient service from the branch offices of the Caja which are located in every region where DIA maintains an experiment station.

As soon as DIA was ready to release improved varieties of various crops the Caja Agraria was again called upon to organize seed increase campaigns. The seed campaigns were financed totally by the Caja, which hired agronomists, purchased equipment, and set up seed processing plants in various parts of the country. Improved varieties of corn, beans, wheat, barley, and potatoes have been released by DIA and multiplied by the Caja for sale and distribution. At present approximately 40% of the wheat, 90% of the barley, and about 7% of the corn (approximately 800 tons of seed per year) that is planted annually in Colombia is in improved varieties multiplied by the Caja. Significant amounts of potatoes and bean seed planted by the farmers are also of improved varieties increased by the Caja.

A United States variety of rice, Gulfrose, is now in first increase and ready for release to the Caja for distribution. A mass selection of ryegrass highly resistant to rust is also being increased and will be added to the list of seeds for sale to the farmers of Colombia.

Without the excellent cooperation and adequate financing of the Caja Agraria the seed increase programs would undoubtedly have been greatly retarded.

In order to encourage the already rapid development of all phases of industry and agriculture, the government is stimulating outside capital to come into Colombia. The government is also trying to colonize large areas of unused but potentially rich land by constructing roads and communications and furnishing technical aid. For example, the completion of the railroad and additional feeder roads from Barranquilla to Bogotá along the Magdalena river has opened up a vast area of the country to exploitation.

Excellent support was received from the Colombian government during the year and in addition some funds over and above the regular budget were received for the importation of stock animals for the animal research programs. However, the simultaneous development of three new experiment stations has placed an unusual strain upon the facilities and budget of DIA.

The training program continues to be successful, with nine fellows and scholars studying for M.S. degrees and one studying for a Ph.D. in the United States at the present time. Seven fellows have returned with M.S. degrees during the year.

One important change has been made in the fellowship program for DIA technicians. Past experience has shown that candidates who leave Colombia without a sufficient command of English are at a distinct disadvantage in competition with students from the United States and other foreign countries. After ascertaining from several former fellows that the short intensive English courses offered at various universities are very good but usually insufficient, it was decided that the candidates from DIA should pass an English examination before leaving Colombia. Such examinations, which are approved by the American Universities Language Center in Washington, D. C., and classes in English are given at the Centro Colombo Americano, which is sponsored by the United States Information Service.

PROGRESS

A contest of commercial corn production on a minimum 25-acre field sponsored by the Caja Agraria was held this year for the second time in the Cauca Valley. It is significant that all the five highest yields this year exceeded the highest yield last year. To the farmer who produced 110 bushels per acre with one of the Diacol hybrids went the first prize of $575 and a silver cup. Other prizes were given to the next three highest producers. While less than 10% of the total corn acreage in Colombia has been covered with direct sales of hybrid and improved varieties, it is significant that 80% of the corn acreage in the Cauca Valley is in hybrids developed by DIA. It is known that many farmers buy improved varieties from their neighbors and this would certainly raise the percentage significantly.

The rice program of DIA is gaining momentum. Excellent results have been obtained at Espinal, which is being developed into the main rice experiment station for the country, and at Palmira, where hoja blanca is omnipresent. Extremely heavy attacks of hoja blanca allowed the breeders to select for good resistance in crosses made between the short-grain types which possess resistance to the disease and the susceptible long-grain types generally desirable in Colombia.

Two hundred tons of foundation seed of Nariño, a newly released variety of wheat, resistant to yellow rust, *Puccinia glumarum*, and "enanismo," a dwarfing disease, have been sent to the Caja Agraria for further increase. In addition, the first multilineal variety is being increased for future release. If this type of variety, which is made up of several agronomically identical but genetically diverse lines, continues to be as promising as at present, the future wheat breeding procedures of our program will be modified considerably.

Brown rot of potatoes, caused by *Pseudomonas solanacearum*, was found in the savannah of Bogotá this year in epiphytotic proportions. This disease came somewhat as a surprise since it usually causes major damage only in warmer climates. For example, it is prevalent in various crops in the southern United States but is less severe in the northern parts of the country where the winter and summer temperatures are generally lower. An intensive effort is being made to study the epiphytology of the disease and determine sources of resistance, if any, among the hundreds of breeding stocks available in Colombia.

Excellent results have been obtained in finding field resistance to late blight of potatoes caused by *Phytophthora infestans*. While these types are not immune, they are highly resistant and the number of fungicide sprays can be reduced significantly by utilizing this type of resistance in commercial potato varieties developed by the potato program of DIA.

Rather unusual results have been obtained by the soil scientists, especially with the application of nitrate of soda fertilizers to the red soils around Medellín. Such fertilizers have caused extreme decreases in yields. The application of boron to certain soil types of the Cauca Valley and Popayán has meant the difference between 0 and 100% stands of alfalfa. The difference of reaction of the various species to the application of N-P-K fertilizers is also notable. Pangola grass responds by as much as several hundred per cent of yield to heavy applications of N whereas corn shows almost no response to N after eight consecutive crops in the same soils at Palmira.

It has been observed that various species of legume and grass seed imported from various parts of the United States and Canada give quite different reactions when planted in the short day length of Colombia. Some of the legumes, especially red clover, give extreme types ranging from a small rosette to almost all flowering stalks, depending on the source of seed. Recommendations as to satisfactory sources of seed have been made to the Caja Agraria officials who are responsible for most of the importations of forage seed for the use of Colombian farmers.

Seed of a variety of rust-resistant ryegrass, the first forage species to be improved and released by DIA, is being increased for release to the Caja Agraria next year. Machinery for planting and harvesting this type of crop is almost completely absent in Colombia. Much work must be done on the mechanical planting and harvesting phases of forage seed production before Colombia can hope to become self-sufficient in seed of forage crops.

Certain reports published in Colombia indicate that approximately 15% of the grain produced annually in Colombia is destroyed by fungi and pests. Further studies in DIA on this problem indicate that much can be done to save thousands of tons of grain annually by better drying and storage.

Three growth cabinets have been purchased and are being installed to enable the wheat pathologists to intensify their work, particularly on wheat rusts. A room with partially controlled temperature and light has also been completed. These facilities, along with artificially controlled environment in the greenhouse, have done much to allow the pathology program to conduct more exact studies on wheat rusts and other pathogens than could be done previously.

Experiments with certain bacteria and fungi to control various insects were tried for the first time in Colombia this year with rather surprising results. These results indicate that the use of such methods of control might under certain conditions be useful in Colombia. Much work remains to be done to determine where and when such controls will be feasible.

The number of animals in the dairy herds is limited at present, but the 32 cows which finished lactations at Tibaitatá averaged almost 13,000 pounds of milk this year. As facilities, pastures, and management are improved it is hoped that the herd averages at the other experiment stations can be raised at least to this level.

The first shipment of Holstein and Aberdeen Angus semen imported by DIA has arrived in the country from the United States and several cows have been bred. The semen is stored in liquid nitrogen at −192°C and can be kept for an indefinite period. Semen has been sent to Palmira, Pasto, and Medellín for breeding cattle in the experimental dairy herds at those locations.

The poultry program of DIA has been started. It is significant, as indicating the immediate possibilities of commercial poultry development in Colombia, that the first group of chicks started and sold after 13 weeks at Tibaitatá, and used for experiments to test the effectiveness of local rations, showed a profit of approximately $1.00 (peso) per bird. Work is under way to determine the quantity and quality of locally available feeds. Laying trials are being run, using locally hatched New Hampshire birds and experimental feeds. Selection of high producing birds for future breeding stocks is being done within the New Hampshire stocks.

The dairy and beef barns at Tibaitatá are nearing completion. Electricity and water are now installed in nearly all the animal barns. In spite of the delays in the completion of facilities, significant data are being accumulated in the various animal sections and what is more important, the Colombian personnel are being trained to carry on the experimental work.

Work on the identification and control of parasites infecting sheep in Colombia is now under way. So far, 12 different species of parasites have been definitely identified from sheep intestines. Any one of these species, if left uncontrolled, may be a limiting factor for sheep production in Colombia. Much better management of the flock was experienced this year, with lambing at 95% and mortality down to less than 5%, as opposed to a much higher percentage last year.

PERSONNEL CHANGES

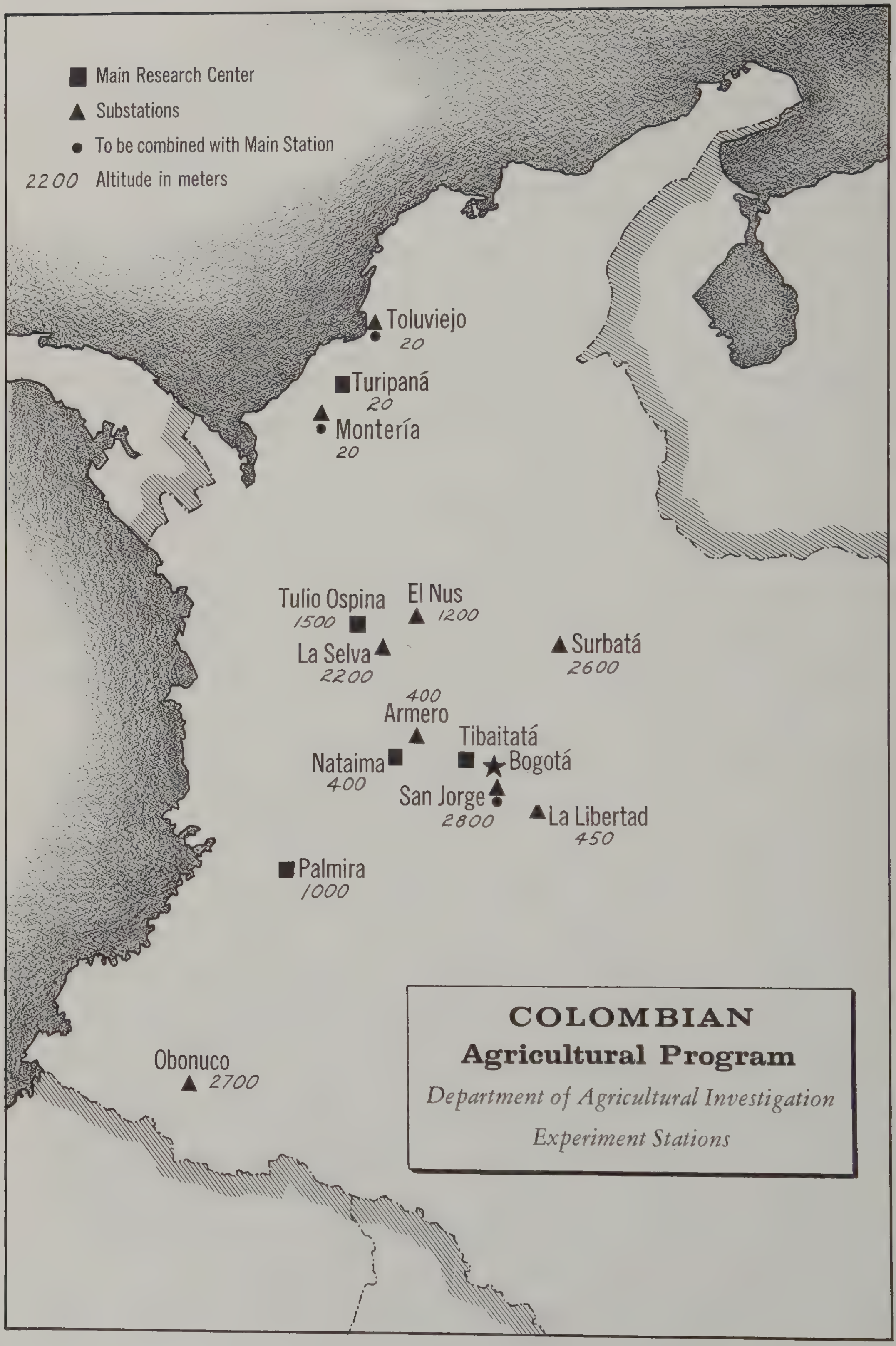
Dr. L. M. Roberts was transferred to the New York office of the Foundation in July, 1959, to become Associate Director for Agricultural Sciences and was replaced by Dr. U. J. Grant as Director of the Colombian Agricultural Program.

Dr. Guy B. Baird was transferred to India as Assistant Director of the Indian Agricultural Program and was replaced by Dr. A. Colin McClung as head of the soil program on April 1, 1960.

Dr. Robert F. Ruppel was granted a study leave at the University of California for the calendar year 1960 and will return near the end of the year.

Dr. Milton Sunde, Professor of Poultry at the University of Wisconsin, spent six months in Colombia helping to organize the poultry work of DIA. He will return to Wisconsin at the end of July, 1960.

A number of temporary scientific aides and consultants visited the program during the year. Their efforts are greatly appreciated by the members of the program staff as well as their Colombian colleagues. Acknowledgment is made in particular to Dr. William I. Myers, Dr. Kenneth L. Turk, and Dr. Alfred M. Boyce, members of the Foundation's Board of Consultants for Agricultural Sciences, and to Dr. Clyde M. Christensen, Professor of Plant Pathology, University of Minnesota.



COLOMBIAN
Agricultural Program
Department of Agricultural Investigation
Experiment Stations

Experiment Stations of the Department of Agricultural Research, Ministry of Agriculture, Colombia.

Location	Name	Size (acres)	Altitude (meters)	Av. temp. (°F.)	Av. rainfall (inches)	Soil types	Principal fields of investigation	Type of agriculture in region served
MAIN STATIONS								
Bogotá, Cundinamarca	Tibaitatá	1,404	2,600	57	29.55	Clay and silt loam	Corn, small grains, potatoes, beans; Horticulture; Forage crops; Soils; Entomology; Animal sciences; Plant and animal pathology	Diversified: all crops and animals
Medellín, Antioquia	Tulio Ospina	408	1,500	70	63.04	Loam	Corn, beans; Soils; Entomology; Plant pathology; Poultry	Corn, beans; Beef and dairy animals
Palmira, Valle del Cauca	Palmira	943	1,000	75	40.98	Clay loam	Corn, rice, beans, sugar cane, vegetables; Soils; Entomology; Plant pathology; Animal sciences	Corn, rice, beans, sugar cane; Soybeans; Pasture crops; Poultry; Cotton
Espinal, Tolima	Nataima	553	400	83	68.56	Sandy loam	Rice, vegetables; Forage crops; Soils; Entomology	Corn, rice; Sesame; Cotton; Beef animals
Cereté, Córdoba	Turipaná	4,495	20	82	41.76	Clay loam	Corn; Forage crops; Entomology; Animal sciences; Plant and animal pathology	Corn; Cotton; Beef animals
SUBSTATIONS								
Pasto, Nariño	Obonuco	1,421	2,700	55	35.46	Silt loam	Small grains, potatoes; Entomology; Dairy animals; Plant and animal pathology	Small grains, potatoes; Beef and dairy animals
Bonza, Boyacá	Surbatá	184	2,600	59	31.13	Clay	Small grains, potatoes	Small grains, potatoes; Beef animals
Soacha, Cundinamarca	San Jorge	1,929	2,800	56	27.58	Clay	Sheep; Animal pathology	Sheep; Potatoes
Rionegro, Antioquia	La Selva	168	2,200	63	55.16	Silt loam	Corn, potatoes, beans, vegetables; Forage crops; Entomology; Plant pathology	Corn, potatoes, beans; Dairy animals
Villavicencio, Meta	La Libertad	3,336	450	79	167.84	Loam	Beef animals; Animal pathology	Rice; Beef animals
San José, Antioquia	El Nus	2,716	1,200	75	88.73	Loam	Beef and dairy animals; Animal pathology	Beef animals
Armero, Tolima	Armero	1,656	400	84	72.89	Sandy loam	Beef animals; Animal pathology	Corn, rice; Sesame; Cotton; Beef animals
Toluviejo, Bolívar	Toluviejo	2,660	20	82	22.66	Sand	Beef and dairy animals; Animal pathology	Cotton; Beef and dairy animals

Corn harvest at Medellín.

Corn

The primary objective of the corn program in Colombia is to increase production. To achieve this goal, emphasis has been placed on the training of Colombian agronomists to carry out a sound breeding program and on the coordination of their efforts. The other activities of the corn program include the production and processing of seed, the holding of cooperative demonstrations and yield trials with extension agronomists, and aid to the dissemination of information pertaining to genetically improved corn and cultural methods by pamphlets, expositions, and extensionists. During the past year, four new corn varieties were released for commercial production: two double-cross hybrids, one modified hybrid, and one synthetic variety.

Corn is one of the most widely grown basic food crops of Colombia, its acreage exceeded only by coffee and plantains. It is planted at elevations from sea level to about 10,000 feet, in extremely variable climates, including hot semi-deserts, tropical areas with an average annual rainfall of about 30 feet, tropical and semitropical Mediterranean climates, and cool Alpine-like climates. These varying climates create special environments and problems relating to insects, diseases, and the inherent adaptability of different stocks of corn, which are, in addition, closely associated with altitude. To provide fair coverage of the many climatic conditions under which corn is grown and to alleviate the problems which occur, breeding investigations are conducted at five main stations located near Montería (50 meters above sea level); Palmira (1,000 meters); Medellín (1,500 meters); Rionegro (2,200 meters); and Bogotá (2,600 meters).

In many areas of Colombia, cultural methods of growing corn are much the same as at the time of the Spanish conquest. Land is prepared by wooden plows or heavy hand hoes, and four or five seeds are dropped into holes made with wooden dibble sticks. Subsequent cultivation usually consists of weeding and hilling-up, combined into one operation; harvesting is usually done by hand. Practically all subsistence-level farmers and agricultural tenants grow corn in this manner, and the acreage under this type of cultivation, which is practiced particularly at elevations over 3,000 feet, probably exceeds 400,000 to 500,000 hectares. In the more highly developed agricultural regions, however, progressive farmers use the most advanced mechanical methods, including irrigation and airplane spraying for insect control.

To demonstrate better cultural practices to Colombian farmers, promising hybrids and synthetic varieties are yield-tested at a number of branch stations and private farms. These trials also serve to provide the breeding program with information on the adaptive properties and yields of the newer corns.

The training of Colombian agronomists is being accomplished by arranging for their direct participation in the crop improvement and research program and, later, their assumption of the responsibilities involved in such a program. In addition to his routine duties in the breeding program, each agronomist is in charge of a special research study, fundamental or basic in nature, which is used as a thesis or submitted for publication in a scientific journal. These research problems are often modified so that basic and practical information can be obtained, to the benefit of both agronomists and programs. Early in the year, one Colombian agronomist was awarded a fellowship for advanced training at the University of Florida.

Races and Collections

For thousands of years, Indian tribes of the Western Hemisphere have maintained genetically diverse strains of maize. With the advent of improved corns and greater rapidity of travel, these strains, often highly specialized, have been gradually disappearing. To prevent the irretrievable loss of genes in these varieties, the Committee on Preservation of Indigenous Strains of Maize was formed in the National Academy of Sciences—National Research Council to sponsor a project in cooperation with The Rockefeller Foundation. The purpose of this project is to collect, preserve, and study for future use as many strains of indigenous corn as possible. The collections from Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela have been completed, and are maintained at the Andean Maize Germ Plasm Bank in Medellín. Additional collections are still being received in small quantities from isolated special areas. Twenty-six new collections were received during the past year, and the total number of collections received to date is 5,962. Last year, seed was sent to 24 different areas of the world.

A great deal of effort has been expended in increasing and maintaining these collections. The maintenance of the collections has been less difficult recently, since descriptions of the races of maize in some of the countries have been completed and it is now possible to mix some of the similar collections into composites. Increases of the race composites and typical collections of the Colombian races of maize were continued in order to store 15-pound samples at the Germ Plasm Bank in Medellín, and also at the National Seed Storage Laboratory in Fort Collins, Colorado.

Although a comprehensive survey of all the collections has not yet been made, genes have already been found for high yielding ability, resistance to corn rust caused by *Puccinia polyspora*, and resistance to a number of other diseases and insects.

The bulletin entitled "Races of Maize in Bolivia" has been completed and forwarded to the National Academy of Sciences—National Research Council for publication in their series on races of maize. Another bulletin, "Races of Maize in Chile," is nearing completion and is to be published in the same manner.

Detailed studies of collections from Venezuela and Ecuador have been continued so that bulletins concerning the races of maize in these countries can be completed during the coming year. This work is being carried out with the collaboration of Dr. Edgar Anderson of Washington University, St. Louis, Missouri, and Dr. W. L. Brown, of Pioneer Hi-Bred Corn Company, Johnston, Iowa, who are representing the Committee on Preservation of Indigenous Strains of Maize, National Research Council. Cytological studies are being conducted by Dr. Barbara McClintock of the Carnegie Institution of Washington, Cold Spring Harbor, Long Island, New York.

Breeding Program

Double-cross hybrids have proved to be the most practical way of utilizing heterosis (hybrid vigor) from the point of view of seed production, as well as of yield output. Many of the mountainous and lowland fringe areas of Colombia, however, are unsuitable for the growing of hybrid corn because many farmers with small landholdings replant seed from their harvest or sell it to their neighbors for planting. This practice results in yield reductions of from 15% to 30% in the case of hybrid corn. In areas and under conditions such as these, there is a real need for genetically broad-base synthetics (reconstituted varieties) which will enable farmers to replant harvested seed without experiencing drastic yield reductions. Furthermore, synthetics of good agronomic type and high yield will serve the marginal areas of production, which have environmental conditions different from those of the breeding and testing centers.

A brief summary of the phases of the breeding program is presented in Table 1.

HYBRID PROJECT

During the past year a new yellow hybrid, designated Diacol H-301, was released by the Medellín station for cultivation in intermediate climates at 1,200–1,700 meters above sea level. It has yielded as high as 7.9 tons per hectare, with an average yield 25% higher than its predecessor, Diacol H-203, over a four-semester period. This new hybrid is

TABLE 1.

A brief summary, by phases and locations, of the activities of the Colombian corn breeding program during 1959.

	LOCATION								
			Tulio Ospina		Palmira		Montería		
PHASE	Tibaitatá[a]	La Selva	A[b]	B	A	B	A	B	TOTAL
Colombian varieties in observation trials	79	39	45	4	55	39	23	27	311
Foreign varieties and collections in observation trials	1,123	67	255	182	847	65	6	43	2,588
Inbred lines of increase and observation	2,181	337	570	1,087	1,219	945	1,377	963	8,679
Lines tested in topcross yield trials	1,357	0	283	231	2,019	1,745	236	430	6,301
Number of yield trials	25	2	14	13	31	30	20	33	168
Double crosses tested in yield trials	0	0	154	171	180	126	283	252	1,166
Single crosses tested in yield trials	181	0	90	108	50	40	221	305	995
Intervarietal crosses tested in yield trials	136	32	28	0	0	18	0	90	304
Entries in yield trials	2,269	99	682	502	2,687	1,833	1,592	1,026	10,690
Hectares in experimental work	33	7	13	13	22	18	0	19	146

[a] There is only one planting each year at the Tibaitatá and La Selva stations.

[b] A=first semester, March–August; B=second semester, September–February.

moderately resistant to prevalent leaf diseases with about 35% of the plants bearing two ears; the ear is thick, slightly conical with regular rowing of deep grains possessing a light flour cap. This hybrid will be produced using cytoplasmic male sterility and fertility restoration genes.

A new white hybrid, Diacol H-352, was also released by the Medellín station for climates between 1,200–1,700 meters above sea level. This hybrid has yielded 7.3 tons per hectare, with a two-semester mean yield 42% over its predecessor, Diacol H-251. The plants of Diacol H-352 are moderately resistant to the prevalent leaf diseases, and about 20% of the thick-stalked plants have two ears; the ears are cylindrical with regular rowing of wide hard flint grains having a slight flour cap.

Yield data concerning the two new hybrids are presented in Table 2.

TABLE 2.

Comparison of yields of new yellow hybrid, Diacol H-301; its predecessor, Diacol H-203; new white hybrid, Diacol H-352; its predecessor, Diacol H-251; and the native variety, Amagaceño.

Variety	Yield (ton/ha.)	Percent of predecessor	Percent of native variety
H-301	5.5	125	183
H-203	4.4	–	147
H-352	6.0	142	200
H-251	4.3	–	143
Amagaceño	3.0	–	–

SYNTHETIC PROJECT

Synthetics will be commercially important because of planting systems practiced by farmers over a wide range of environmental conditions. In addition, the frequencies of favorable genes in synthetics can be increased by using certain techniques, thereby building up pools of highly favorable germ plasm which serve as excellent sources of breeding material.

A first-cycle yellow synthetic of the Montería station is yielding 25% more than the presently recommended yellow variety, while a white first-cycle synthetic is yielding 5% more than the recommended white hybrid. These synthetics are being recycled to increase the favorable gene frequencies and if the favorable performance of the yellow synthetic continues, it will be released in the near future. Six new synthetics are also in yield trials at Palmira and Medellín.

A new yellow synthetic, Diacol V-502, was released by the Bogotá station for areas 2,300 meters above sea level. The plants of this synthetic are fairly short and exhibit a good deal of resistance to prevalent leaf diseases. The ears are somewhat conical with 12 to 14 rows of large round flour grains. The mean yield of Diacol V-502 is 10% higher than the yields of the commonly grown varieties in the widely separated locations in which tests have been conducted.

INTERVARIETAL CROSSES

Intervarietal crosses are receiving increased attention, and 304 families of intervarietal crosses were tested at the five breeding centers; these trials are being repeated. The families usually consisted of the two parents, the cross, one or two advanced generations of the cross, and in some cases, backcrosses of the F_1 to the parents. This type of study will serve as a means of selecting varieties which exhibit a high degree of heterosis for ultimate utilization in double-cross hybrids. The research will also facilitate selection of material for the formation of synthetic varieties and may possibly indicate which type of selection might be used most profitably. Data on the effects of gene action may also be obtained from these trials.

As a result of these studies, a yellow varietal cross, Diacol H-501, was released by the Bogotá station for areas over 2,300 meters above sea level. This F_1 hybrid of two varieties has yielded as high as 7.6 tons per hectare and in tests conducted on a three department basis, the F_1 yielded 28% more than the regional varieties; 25% more than the average of the two parents; and 16% more than the highest-yielding parent. The plants of Diacol H-501 are low and have a high degree of resistance to the common leaf diseases. The low ears are characterized by 12 to 14 rows of large round flour grains. Although many farmers will save the commercial seed of this hybrid for planting and thus realize an 18% reduction of yield, they will still harvest more corn on the average than if they had planted an unimproved local variety.

SPECIAL STUDIES

A very expensive operation in the production of hybrid seed corn is detasseling, i.e., removing the male inflorescence from the inbred line or single cross that is used as the female parent. By using appropriate techniques, specific genes may be incorporated into specific types of cytoplasm. The interaction of these genes and cytoplasm causes the male flower to malfunction, therefore producing male sterility. Still other genes are able to restore fertility. Utilization of these genetic systems permits hybrid seed production at a lower cost than would be possible otherwise. Two of the hybrids now in commercial production are produced by using cytoplasmic male sterility and fertility restoration. Steps are being taken so that all new hybrids will be produced in this manner.

From preliminary data, it appears that one of the Colombian sources of cytoplasmic male sterility is different from the Texas source, and also that a number of fertility restoration genes from local material react in a differential manner with the two types of cytoplasm. These studies are being continued not only for local application but also for potentially beneficial application in many other parts of the world.

Studies on the mode of gene action are being conducted with seven varieties which possess exceptionally high hybrid vigor in certain intervarietal crosses. The determination of the genetic situation in some of these varieties, if it is possible, will provide a sounder basis for planning the direction that certain phases of the corn program should take. These data may also indicate that certain types of selection and breeding procedures would result in much higher-yielding corns than would others. In conjunction with this research, a number of the same varieties are also being studied in relation to the formation of synthetics when different methods of selection and selection pressures are employed.

Stalk damage caused by an insect, *Diatraea* spp., and associated fungi is a serious problem in the lowland tropics. A number of inbred lines with a high degree of resistance or tolerance have been selected at the Montería station in cooperative work with the entomology program. This work and related studies are being continued to determine which lines can be used to greatest advantage in developing resistant hybrids and synthetics.

Ear rots caused by *Fusarium* spp. and *Diplodia* spp. are estimated to reduce by as much as 5% to 15% yields of corn grown in areas over 1,000 meters above sea level. Continuing cooperative work with the plant pathology section has shown that four lines appear to be highly resistant to both fungi, and that a number of other lines are resistant to one or the other fungus. Other studies to isolate material resistant to the incitant of leaf blight, *Helminthosporium turcicum*, are also being conducted.

SEED INCREASE CAMPAIGN

After a new corn has been released by the breeding program, the foundation seed stocks are turned over to the seed increase campaign of the Caja Agraria for increase to commercial quantities, processing, and subsequent sale to the farmer. Seed sales have increased steadily since 1953, except during 1958–1959, when a very unstable and unrealistic market situation was created. Annual seed sales from 1953 to May, 1960, are shown in Table 3.

TABLE 3.

Annual seed sales of hybrids and improved varieties released by the Colombian corn breeding program from 1953 through 1960.

Year	Tons of seed sold
1953–1954	115
1954–1955	262
1955–1956	488
1956–1957	624
1957–1958	739
1958–1959	463
1959–1960	823

A large portion of the seed sold by the seed increase campaign is planted in the fertile Cauca Valley where, it is estimated, between 80% and 85% of total corn acreage is planted with hybrid corn or synthetic varieties. The estimated acreage planted with improved seed in the entire country is between 6% and 8%. Assuming a maximum yield of 2 tons per hectare for unimproved corns, a conservative average of 3.5 tons per hectare for improved corns, 15 kilos of seed to plant a hectare, and a market price of 500 pesos per ton of commercial corn, the seed sold by the seed increase campaign to date represents an increased value of 175,650,000 pesos to the Colombian farmer, including 41,000,000 pesos for 1959–1960 alone. Many of the progressive farmers in the Cauca Valley have obtained yields of over 5 and 6 tons per hectare, based on yields of 10 plaza (about 15 acre) blocks selected at random within their fields. The increased value of improved seed under these conditions is readily appreciable.

The new wheat variety, Nariño 59.

Wheat

Although wheat production in Colombia rose to 180,000 metric tons during 1959, it was necessary to import an additional 82,000 tons to meet the demands of local consumption. Of the national production, 95% was grown in the Departments of Boyacá, Cundinamarca, and Nariño, at elevations of from 1,700 to 3,000 meters and at average annual temperatures of from 5° to 7°C. If it were possible to produce varieties which would do better in warmer climates at lower elevations, the area suitable for wheat production in Colombia could conceivably be extended enough so that production adequate for local consumption could be achieved. Considerable interest is being shown in exploring this possibility, and a special program will probably be initiated during 1960 or 1961.

Resistance to disease, particularly to yellow rust, remains of paramount importance in improving Colombian wheats, although high yield, acceptable milling and baking quality, adequate straw strength, and sufficient earliness to allow two crops to be grown per year are also factors of immense importance.

The old improved variety Menkemen no longer carries adequate resistance to yellow rust and other diseases, and is considered susceptible enough to be used as a source of inoculum in experimental nurseries. The variety Bonza, more recently released by the Colombian program, remains superior to native selections, such as Ciento Cincuenta and Bola Picota, and increased yields obtained by growing this variety represent several million pesos of additional income to Colombian farmers.

New Variety

Two hundred and fifty tons (sufficient to plant 2,500 hectares) of the new wheat variety Nariño 59 were turned over to the seed campaign of the Caja Agraria. This variety is adapted to areas over 2,500 meters above sea level where yellow rust is a problem, and is particularly suited to the high zones of the Department of Nariño, where it is resistant to both yellow rust (stripe rust) and the dwarfing disease enanismo. Nariño 59 is not so highly recommended for cultivation at altitudes below 2,500 meters above sea level because under optimum conditions for the rust organism, which occur in such locations, stem rust can lower its yield appreciably. In its zone of adaptation, Nariño 59 yields about 20% more than the Bonza variety, has moderately strong straw, and produces a very good bread flour.

TRIALS

Regional yield and adaptation trials were continued in the three principal wheat zones in Cundinamarca, Boyacá, and Nariño, in cooperation with the Caja Agraria and Procebada. In these trials, the final experimental stage before commercial release of recommended varieties, yield, resistance to disease, and adaptation of the best lines from the breeding programs are checked, in order to determine the most suitable varieties for each region.

The normal regional yield trials were supplemented during the past year by an emergency program, conducted in the lower elevations of Nariño in cooperation with the Caja Agraria. The adapted improved variety Menkemen normally grown in these zones was destroyed by a new race of stem rust. A separate nursery of 400 advanced generation hybrids and varieties from the Nariño breeding program was planted at Rosal del Monte, at an elevation of 2,100 meters. All but about 10% of the nursery was either not adapted or was susceptible to stem rust. Testing will be continued in an attempt to select a variety for this zone.

BREEDING PROGRAM

The multilineal phase of the breeding program has been expanded, since many of the backcross lines of both the Frocor and Bonza composites are entering preliminary testing. The regular breeding nursery and the special nursery of dwarf lines were also maintained.

The numbers of lines studied in the varied phases of the breeding program are summarized in Table 1. Data concerning some of the more promising lines of wheat from the Colombian program are presented in Tables 2, 3, and 4. It is interesting to note (Table 4) that several of the experimental lines compare quite favorably in milling and baking quality with hard red winter wheats from outside the country.

COLOMBIAN-ECUADORIAN WHEAT PROGRAM

The cooperative Colombian-Ecuadorian wheat program has reached the stage at which

TABLE 1.

Number of wheat lines studied in Colombia during 1959.

	Number of lines grown at:					
Generation or experiment	Tibaitatá	Surbatá	Obonuco	Rosal del Monte	La Selva	TOTAL
F_1	–	1,314	–	–	–	1,314
F_2–F_8	22,998	18,026	–	–	–	41,024
Yield trials	1,292	1,560	843	350	50	4,095
Multiplication blocks	3	2	3	–	–	8
Small multiplication blocks	75	–	103	100	–	278
Purification lines	6,835	–	–	–	–	6,835
Miscellaneous	817	238	–	–	–	1,055
TOTAL	32,020	21,140	949	450	50	54,609

TABLE 2.

Yields in percentage of Bonza of 13 promising hybrid-derived lines as compared to native and improved check varieties of wheat in Colombia in 1959.

Name and number of cross or variety		1959A[a]			1959B
		Yield trials Tibaitatá	Small plots Tibaitatá	Yield trials Surbatá	Yield trials Obonuco
(Frocor-Frontana/Yaqui × 4777) × Frocor/Mayo 54-4777	9858-12t-4b-1t	138	169	109	170
Frocor-Frontana/Yaqui × 4777	9314-22t-1b-1t	150	172	98	–
Diacol Nariño		126	134	107	229
Frocor-Frontana/Yaqui × 4777	9314-10b-6t-3b-1t	133	155	96	–
Bonza sib × Frontana/Thatcher-Thatcher/Mentana	9796-2b-4t-2b-1t-2b	112	175	109	–
Thatcher-St. Catalina × Kentana-Frontana	6699-1b-4t-78t	117	144	96	144
(Frocor-Kenya Farmer/Gabo × 4777) × Frocor/Mayo 54-4777	9867-6t-2b-1t	117	165	96	–
Frontana/Yaqui-Mayo 54 × Menkemen	10668-4t-2b-1t	112	159	98	–
Frocor-Frontana/Yaqui × 4777	9314-10b-8t	119	175	86	–
(Frocor-Kenya Farmer/Gabo × 4777) × Frocor^2	11055-12t-1b-3t	112	175	88	–
Cometa-Newthatch/Mentana × Frocor	7718-2b-2b-1t-1b-1t-1b	82	148	114	–
Bonza (Improved check variety)		100	100	100	100
Menkemen (Improved check variety)		100	130	86	38
Ciento Cincuenta (Native check variety)		83	–	77	–

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[a] A=first semester, March–August; B=second semester, September–February.

TABLE 3.

Disease development of promising hybrid-derived lines of wheat grown at three locations in Colombia during 1959.

Name and number of cross or variety		Yellow rust			Stem rust			Enanismo
		1959A[a]	1959A	1959B	1959A	1959A	1959B	1959B
		Tib.[b]	Surb.	Obon.	Tib.	Surb.	Obon.	Obon.
(Frocor-Frontana/Yaqui × 4777) × Frocor/Mayo 54–4777	9858-12t-4b-1t	0	0	0	0–TMR[c]	5R	0	10
Frocor-Frontana/Yaqui × 4777	9314-22t-1b-1t	0	0	–	TR	0–TR	–	–
Diacol Nariño		0	0	0	0	0–TR	0–5MR	10
Frocor-Frontana/Yaqui × 4777	9314-10b-5t-3b-1t	0	0–5MR	–	0–TR	0	–	–
Bonza sib × Frontana/Thatcher-Thatcher/Mentana	9796-2b-4t-2b-1t-2b	0	0	–	0	0–TR	–	–
Thatcher-St. Catalina × Kentana-Frontana	6699-1b-4t-78t	0	0	20MS	0	10MS	TR	15
(Frocor-Kenya Farmer/Gabo × 4777) × Frocor/Mayo 54–4777	9867-6t-2b-1t	0	0	–	0	5R–5MR	–	–
Frontana/Yaqui-Mayo 54 × Menkemen	10668-4t-2b-1t	0	0	–	0	0	–	–
Frocor-Frontana/Yaqui × 4777	9314-10b-8t	0–TR	0	–	TR	TR	–	–
(Frocor-Kenya Farmer/Gabo × 4777) × Frocor^2	11055-12t-1b-3t	0	0	–	TR	TR	–	–
Cometa-Newthatch/Mentana × Frocor	7718-2b-2b-1t-1b-1t-1b	0	0	–	0	TR	–	–
Bonza (Improved check variety)		0–5MS	0–5MR	20S–20MS	0–TMR	TR–TMS	0–5R	25
Menkemen (Improved check variety)		0–20S	30S–50S	60S	5MS–20S	40S	TR	30
Ciento Cincuenta (Native check variety)		5R	0–TR	10MS–5S	TR	20MS	5MR–5MS	5

[a] A = first semester, March–August; B = second semester, September February.

[b] Tib. = Tibaitatá; Surb. = Surbatá; Obon. = Obonuco.

[c] T = traces, R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible.

TABLE 4.

Quality of promising hybrid-derived wheat lines from Colombia.

Name and number of cross or variety		Grain type[a]	Lb./ bu.	Hard-ness index[b]	% protein in flour	% flour extrac-tion	% water absorp-tion	Mixing time (min.)	Loaf volume (c.c.)	Color[c]	Milling ability[a]	Baking ability[a]
(Frocor-Frontana/Yaqui × 4777) × Frocor/Mayo 54–4777	9858–12t–4b–1t	G-HRW	63	37	10	73	71	2.50	795	90g	VG	G
Frocor-Frontana/Yaqui × 4777	9314-22t-1b-1t	G-HWW	63	36	10	73	70	2.25	665	85y	VG	G
Diacol Nariño		G-HWW	63	39	11	76	62	1.50	765	90g	VG	VG
Frocor-Frontana/Yaqui × (Frocor × McMurachy/Kentana-Yaqui)	9314-10b-6t-3b-1t	G-SWW	63	40	12	77	73	2.00	890	95y	VG	VG
Bonza sib × Frontana/Thatcher-Thatcher/Mentana	9796-2b-4t-2b-1t-2b	G-HWI	61	40	11	73	68	3.00	730	80c	VG	G
Thatcher-St. Catalina × Kentana-Frontana	6699-1b-4t-78t	G-SRW	64	36	12	75	70	1.50	795	95g	VG	G
(Frocor-Kenya Farmer/Gabo × 4777) × Frocor/Mayo 54–4777	9867-6t-2b-1t	E-HWS	64	38	12	75	71	2.00	900	100c	VG	E
Frontana/Yaqui-Mayo 54 × Menkemen	10668-4t-2b-1t	G-SRW	63	47	11	76	71	2.50	810	100g	VG	VG
Frocor-Frontana/Yaqui × 4777	9314-10b-8t	G-SWW	63	44	11	73	71	2.00	910	90y	VG	VG
(Frocor-Kenya Farmer/Gabo × 4777) × Frocor^2	11055-12t-1b-3t	G-HWW	61	45	11	74	72	1.50	970	95c	VG	VG
Cometa-Newthatch/Mentana × Frocor	7718-2b-2b-1t-1b-1t-1b	G-SRI	62	40	12	76	71	1.50	855	95y	VG	VG
Bonza (Improved check variety)		G-SRS	64	45	11	77	65	1.50	710	95y	VG	G
Ciento Cincuenta (Native check variety)		G-HRS	64	40	12	74	73	3.00	760	90c	VG	G
Hard Red Winter (Imported check variety)		G-HRW	65	33	11	75	77	4.50	775	95c	VG	VG

[a] Classified according to the standards of the international market: E=excellent, G=good, VG=verygood, S=soft, H=hard; RW=red winter, WW=white winter, RS=red spring, WS=white spring.

[b] 35 and less=hard, 35–40=medium, 40 and more=soft.

[c] 100%=ideal; c=cream, g=gray, y=yellow.

Bread of the new wheat variety Nariño 59 (No. 6) compared with other varieties. Numbers 1 and 7 are standard laboratory checks.

the first fixed lines have been placed in regional yield and adaptation trials. The experiment station of the program has been moved from Izobamba down to Santa Catalina, part of the same hacienda, under a ten-year rental arrangement. This location is to serve temporarily, until the government organizes its department of investigation and purchases an experiment station. Ing. Agron. Pablo Larrea was sent to Mexico for training with the Mexican wheat program.

INTERNATIONAL COOPERATION

The International Stem Rust Nurseries were planted at the experiment stations, and the interchange of genetic material with Mexico, Chile, Kenya, and Peru was continued. Altogether, during the past year, a total of 9,412 genetic lines were sent, as follows: Kenya, 1,739; Chile, 1,739; Ecuador, 2,331; Mexico, 1,739; Peru, 1,739; Venezuela, 75; and the Dominican Republic, 50.

Preliminary multiplication of new barley varieties.

Barley

More barley was produced in Colombia during 1959 than has ever before been possible. The estimated national production was 105,000 metric tons, more than double the 1955 yield of 52,000 tons and nearly 44% more than the 1958 production of approximately 73,000 tons. The increase can be attributed to the use of better seed and improved cultural practices and to the availability of better credit and markets. Despite the rise in production, however, it was necessary to import an additional 25,000 tons of malt.

The Funza variety, released by the barley program in 1955, accounted for 90% of the barley grown in Colombia during the past year, and approximately 70% of the total barley crop was produced in the Department of Cundinamarca, with 15% and 10% grown in Boyacá and Nariño, respectively.

The operation of the barley improvement program, as well as of the other two small-grain programs, continues to be hampered by the resignations of agronomists to accept higher-paying positions. Seven agronomists have left during the past year and because of this reduction in personnel each of the three programs has been cut by 50%, by planting one crop, rather than two, during the year. The crops are rotated so that a full crew of agronomists can work on each crop, at least at the Tibaitatá central station.

Breeding and Testing

The general objective of the barley improvement program is to develop earlier, higher-yielding varieties which incorporate greater disease resistance and better malting and brewing qualities and produce shorter, stronger straw. Table 1 presents a summary of the numbers of lines studied in various phases of the program during the past year in the attempt to realize this goal.

A major project has been the continuation of varietal testing in regional and experiment station yield trials, in an effort to find a variety which offers greater disease resistance and better straw than does Funza. Several varieties have proved superior (as shown in the data presented in Table 2) but a decision on multiplication must await the outcome of quality tests, which are being processed through Procebada.

The variety Galeras, resistant to the dwarfing disease enanismo, underwent its first quality test on a commercial scale. Although it proved superior to the native barleys, which are mixtures of several types, Galeras was still low in quality, producing a somewhat bitter taste. To find a replacement variety, over 500 resistant lines are being studied in comparative field tests with Galeras. A lack of facilities for quality testing has somewhat impeded the project, but the start of operations in 1960 of the quality laboratory of United Malting Co. is expected to improve the situation.

During the past year, greater emphasis has been placed on incorporating quality into the high-yielding, good-strawed, adapted varieties both for the enanismo disease zone of Nariño and for the rest of the country. With this objective in mind, the smut-resistant, high-quality barley variety Toluca, developed by the Mexican program, has been used extensively in crosses, particularly with Funza and Galeras derivatives. Field selections were made in segregating lines with primary emphasis on using the agronomic indicators of quality such as Manchurian head and grain type. In this way, it should be possible to up-grade the potential for quality of the entire nursery.

SPECIAL STUDIES

A special study on the inheritance of enanismo resistance, under way at Obonuco, Nariño, had a setback when the nursery was so heavily attacked by the disease that even the resistant material could not be identified with certainty.

A study on the control of loose smut was suspended upon the resignation of the agronomist in charge.

INTERNATIONAL COOPERATION

The International Barley Disease Nursery was again planted this year at Tibaitatá, Surbatá, and Obonuco. Seed samples of a total of 2,841 lines were sent as follows: Kenya, 288; Mexico, 288; Peru, 1,849; Chile, 288; Guatemala, 61; Venezuela, 25; and the United States, 42.

TABLE 1.

Number of barley varieties and lines studied in Colombia during 1959.

	Number of lines grown at:								
	Tibaitatá		Surbatá		Obonuco		La Selva		
Generation or experiment	1959A[a]	1959B	1959A	1959B	1959A	1959B	1959A	1959B	TOTAL
F_1	1,800	–	–	–	278	–	–	–	2,078
F_2–F_7	11,366	10,807	–	–	1,548	–	–	–	23,721
Yield trials	375	175	375	–	375	236	25	–	1,561
World collections	6,528	6,528	–	–	–	–	–	–	13,056
Small plots	36	50	36	–	–	–	–	–	122
Disease nursery	170	161	170	–	–	–	–	–	501
Multiplication	11	–	–	–	–	–	–	–	11
Miscellaneous	206	204	193	–	–	–	–	–	603
Regional trials	13	–	–	–	–	–	–	–	13
TOTAL	20,505	17,925	774	–	2,201	236	25	–	41,666

[a] A = first semester, March–August; B = second semester, September–February.

TABLE 2.

Comparisons of some promising hybrid-derived lines of barley grown at two locations in Colombia during 1959.

Name and number of cross or variety	SURBATÁ 1959A[a]				TIBAITATÁ 1959B				
	Yield in percent of Funza	Percentage of disease development			Yield in percent of Funza	Percentage of disease development			
		smut	scald	stem rust		smut	scald	leaf rust	stem rust
Desconocida-Pocha × Ogalitsu-Jet II-1346-4b-1t-2b-3t	147	0	0	5MR[b]	75	0	0	5MR	5MS–5S
CI.6978/Funza-Ogalitsu/Funza × Bachué II-1612-4b-1t	142	15	10	5MS	112	2	0	50S	40S
Desconocida-Pocha × Atzel/Común-Funza/CI.5649 II-1406-8t-2b-3t	140	5	5	0	90	2	0	5MR	20S
(1226-DC.23/Montcalm × Peatland-Raspa) × Bachué^{3} III-2555-2b	132	5	20	5MS	110	12	0	10MR	5S
Funza-1102 × Funza II-872-4b-1b-7t-2b	115	5	5	20S	92	1	5	30S	50S
Desconocida-Pocha × (Giza. 68 × Pocha/Raspa-Kindred) II-1422-5t-3b-2t	110	0	15	5MS	115	4	0	20S	30MS–10S
Funza (Improved check variety)	100	5	5	20S	100	2	5	25S	10S
Pocha (Native check variety)	90	5	0	5MS	72	2	5	5MS	50S

[a] A = first semester, March–August; B = second semester, September–February.

[b] R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible; T = trace.

Oats—a promising silage crop.

Oats

There is considerable interest in Colombia in raising the level of the country's oat production, which is negligible at the present time. Oats produce extremely large amounts of forage in Colombia and yields of up to 70 metric tons per hectare of wet forage have been obtained in forage experiments; the additional benefits of two crops or two cuttings per crop can almost certainly be realized with well-adapted varieties. Oat silage would be of tremendous value to dairy and other livestock enterprises, and commercial oat companies and an ever-increasing commercial feed industry also offer potential markets for oat grain, if it can be produced reliably and economically.

Crown rust and the enanismo dwarfing disease are serious problems in the cultivation of oats in Colombia, but the principal difficulty at the present time is stem rust. Since the initiation of the oat improvement program in 1957, several groups of lines have been selected as rather highly resistant to the stem-rust pathogen, only to have their resistance break down in a short time. One variety, C.I. 6969, was near release when such a breakdown occurred. This phenomenon would seem to indicate a rapidly changing stem-rust picture. While there has not been time, until now, to make adequate race identification, growth chambers are presently being installed at Tibaitatá and should greatly facilitate studies in the stem-rust race situation.

The oat improvement program received a setback in 1959 with the appearance of a new, highly virulent race (or races) of stem rust, which eliminated two lines that were being multiplied and limited to 93 lines the harvest from 1,131 promising lines of the U. S. Department of Agriculture world collection. However, 525 advanced lines with a good degree of resistance were harvested and have been seeded in the first semester (March-August) of 1960. This material, after two severe screenings to biotypes of stem-rust races 7, 13, and others, should represent the most promising sources of resistance for Colombian conditions. Another encouraging fact was that lines from 325 crosses representing a diverse base of germ plasm had sufficient resistance to be worth harvesting.

The Colombian branch of the Quaker Oats Company, which is establishing an oat quality laboratory at its plant in Cali, has expressed a willingness to cooperate in testing promising hybrids from the oat breeding pro-

TABLE 1.

Numbers of lines and varieties of oats studied in Colombia during 1959.

Generation or experiment	Number of lines grown at: Tibaitatá	Surbatá	Obonuco	La Selva	TOTAL
F_1	455	–	–	–	455
F_2–F_5	1,183	–	–	–	1,183
Yield trials	125	125	125	125	500
Small plots	14	14	14	14	56
Multiplication	2	–	–	–	2
Rust nursery	317	200	200	200	917
World collection	1,130	–	–	646	1,776
Miscellaneous	259	–	–	–	259
TOTAL	3,485	339	339	985	5,148

gram, and has also agreed to support a Colombian agronomist to work on oat breeding, completely under the supervision of DIA. It would thus be possible to maintain at least one trained man in research on this crop.

The number of lines and varieties which have been studied in Colombia during 1959 are listed in Table 1. The U. S. Department of Agriculture and several state experiment stations have been most kind in making available new varieties and species collections, and most of these sources have indicated the desire to continue their valuable assistance. It is interesting to note that varieties containing genes for resistance to all known United States races of stem rust are susceptible under Colombian field conditions. The International Oat Rust Nursery was planted at the Tibaitatá, Surbatá, Obonuco, and La Selva experiment stations again this year.

Hoja blanca resistant selections vs. Bluebonnet 50 (center).

Rice

Rice is the most important food crop in Colombian agriculture, as measured by the value of grain production, the investment in machinery and equipment, and the number of farmers and workers employed by the industry. The land area devoted to rice cultivation is in excess of 500,000 acres and the annual production is about 400,000 long tons, which just meets local needs. Large quantities of rice have been neither imported nor exported during the past few years.

About two-thirds of the rice produced in Colombia is grown under upland conditions without irrigation. Yields from upland rice are very low, mainly because of severe weed infestations. The lowland, or irrigated, rice produces higher yields, but even these do not compare favorably with average yields in Spain, Italy, Japan, Peru, or the United States.

The varieties used in irrigated areas are principally United States long-grain rices such as Bluebonnet, Rexoro, and Fortuna, with a small extension devoted to Zenith, a medium-grain rice. Upland rice varieties include those mentioned above, as well as a large number of unimproved native varieties. The consumer strongly prefers long-grain rice, because of its dry cooking characteristics.

The costs of rice production under irrigated conditions range from 1,700 to 1,900 pesos per hectare, and the farmer must harvest about 35 bags (62.5 kg.) to pay these costs. During the past two or three years, however, production per hectare of irrigated rice has averaged from 30 to 35 bags. These conditions place the rice industry in a precarious financial position.

Low average yields are due to three major problems: heavy grass and broad-leaf weed infestations in all rice-growing zones; poor management practices, especially with respect to fertilizer applications, irrigation, and rotations; and recent epiphytotics of the hoja blanca disease in certain areas. This disease has forced the farmers of the Cauca Valley to switch from the highly susceptible Bluebonnet to native types which have low quality but are disease tolerant.

Production practices vary considerably throughout the major irrigated rice zones. In general, farmers adopt one of two practices. Some drill rice into prepared seedbeds, but most of the farmers drop seed onto the seedbed from a grain drill with the spouts and disks removed. This is followed by a light disking to cover the seed. In both methods, from 160 to 250 kg. of seed are used per hectare. The land is flushed to stimulate germination and is then flushed again one or more times to prevent drying of soil. Permanent irrigation is started approximately 30 days after seeding and continued until the harvest, with one or more drainings to permit the distribution of fertilizer by hand. The quantities of fertilizer used and the times of its application vary tremendously. Nearly all fields are hand-cleaned of weeds at least once during the growing period. Mechanical harvest of the grain is common in the irrigated rice zones. Grain is dried on open-air patios and sent immediately to the mill. Two crops are grown each year, frequently on the same ground, and because many farmers rent land, failure to rotate rice with other crops or to leave the land fallow is common.

The rice program received great impetus during 1959 from the initiation of investigation at the new experiment station, Nataima, near El Espinal in the Tolima Valley. During the year, 140 acres of land were planted to commercial rice production, in order to have land well prepared for future investigations and to gain experience in commercial planting and its problems. Approximately 35 acres were devoted to the breeding program and to the investigation of cultural practices.

The Nataima station, with its large extension of land suitable for rice growing and its abundant supply of water for irrigation, will serve as the center for the breeding program and for studies on cultural practices. The Palmira station will continue to operate as a substation for the breeding program.

During the period covered by this report, one Colombian agronomist was awarded a fellowship to the University of Minnesota to begin graduate work. Basic studies were initiated under the direction of two agronomists, and will serve as professional training and as future graduate thesis problems.

Breeding Program

VARIETAL IMPROVEMENT

Hoja blanca, an insect-transmitted virus disease of rice, continued to spread through several important Colombian rice zones and became a threat to the industry, based as it is on highly susceptible long-grain varieties. A backcross program was started in 1958 when the rice section was established. Sources of resistance included several high-yielding Asian varieties of the unpopular short- and medium-grain types. These have been crossed with a number of adapted, high quality long-grain lines. It was early recognized that backcrossing to the long-grain types is necessary to recover the required grain characteristics. Heavy epiphytotics of the disease at Palmira facilitated the selection of approximately 3,500 plants. These will be further screened for resistance and desirable agronomic characteristics and then will be tested in yield trials and large plots when they have reached the F_5 or F_6 generation. One accomplishment of major importance is that resistant long-grain selections can now be used in the single crosses and backcrosses.

In addition to resistance to hoja blanca, many of these selections show other qualities desirable for Colombian conditions; these include rapid germination and seedling vigor, high tillering capacity, medium plant maturity, and resistance to cool weather.

MULTIPLICATION

The multiplication program is presently concerned with the multiplication of the medium-grain variety Gulfrose, which is resistant to the hoja blanca disease. This variety was selected out of several thousand from the International Rice Nurseries tested during 1959–1960. Yield trial data have demonstrated that Gulfrose is superior to the common commercial varieties, both under severe disease conditions and in the absence of infection. The medium-grain type, although not as popular as long-grain rice, should be accepted, at least until long-grain varieties are developed by the breeding program.

International Cooperation

During the period covered by this report, nearly 3,000 lines were received from the cooperating Rice Section of the U. S. Department of Agriculture and tested for resistance to hoja blanca. Selections of this material were incorporated into the breeding program. In addition, a nursery of 663 long-grain selections was sent from Colombia to Venezuela for further testing. It is planned that promising long-grain selections will be sent to the Rice-Pasture Experiment Station, Beaumont, Texas, for quality evaluation.

SPECIAL STUDIES

The improved yields and lower costs which are necessary to the welfare of Colombia's rice industry can be partially achieved by the development of superior varieties in the breeding program. In addition, however, special studies on rice culture are urgently needed to combat the problem of weed infestations and to improve cultural practices. With this in mind, investigations have been begun at the new Nataima station in the Tolima Valley on time and level of fertilizer applications, seeding rates and methods, herbicides, and rotations with other crops. Preliminary results are highly promising, and show that high yields and weed control are possible in seedings using only from 120 to 140 kg. per hectare. At Palmira, studies have been advanced on date of seeding trials, herbicide testing, transplanting methods, and production from the ratoon crop.

Harvesting potatoes at Tibaitatá.

Potatoes

The present emphasis in the activities of the potato section is upon the development, multiplication, and distribution of improved potato hybrids, and on adaptation studies. Cooperation with the plant pathology program has been increased because of recent additional disease problems. Investigations relating to the epidemiology of late blight and the effect of temperature on growth and development of the potato have been conducted, and indicate the importance of these factors on potato production.

Breeding

COLOMBIAN POTATO COLLECTION

The Colombian collection of potato varieties and species has been increased to provide a greater selection of germ plasm required in the expanding breeding program for such factors as increased disease resistance and improved agronomic characteristics. Several varieties of *Solanum tuberosum* L. from the United States which were added to the collection included material resistant to the bacterial disease caused by *Pseudomonas solanacearum* E. F. Sm. Thirty haploid lines derived from *S. tuberosum*, produced at the Potato Introduction Station, Sturgeon Bay, Wisconsin, are being used in the breeding program together with haploid lines produced in Colombia. The haploid condition will promote a high degree of homozygosity and the inheritance of fixed characteristics with less segregation than in the tetraploids now being used. When a large enough reservoir of haploid material has been developed, the incorporation of the many agronomic factors desirable in a variety will be greatly simplified.

The recent collection of over 100 lines of *Solanum phureja* Juz. et Buk., made in Venezuela and Colombia by Drs. Dodds and Paxman of the John Innes Horticultural Institute, Herts., England, is being added to the Colombian collection. This material will provide a wider base of genetic material for the development of haploid clones.

SCREENING OF HYBRID SEEDLINGS

A total of 150,000 interspecific and intervarietal hybrid seedlings and selfed lines were screened in the field during 1959. One hundred thousand of these seedlings were planted for a further evaluation of the more promising crosses produced in 1956 and 1957. Approximately 40,000 seedlings were planted to sample the 200 different crosses made in 1958. The other 10,000 seedlings were planted to select segregating material from selfed lines of varieties showing promise in the breeding program.

The first screening of this material in the field was for field or partial resistance to the late blight disease caused by *Phytophthora infestans* (Mont.) DBy. Further selection was made for freedom from virus diseases. Only 4.5% of the total number of seedlings screened were free from diseases. At harvest time, further screening on the basis of tuber characteristics reduced the total number of lines selected to 203, or approximately 0.1% of the total seedlings planted.

The use of adequate haploid breeding material would substantially reduce the amount of work in the screening of seedlings by reducing the need for large segregating populations to obtain desired qualities in a potato hybrid.

Seed Multiplication

From a group of 300 of the more promising potato hybrids, 39 were selected for advanced yield testing and screening for quality and for ability to withstand storage. Sufficient material is now available so that at least one new potato variety can be released each year to meet the varying demands of the producers and consumers.

The variety Guadalupe was selected for distribution to farmers in 1959, because of the objection that the variety Monserrate produces tubers too large for the market and for seed.

Approximately 800 tons of seed potatoes of the variety Monserrate, produced in 1958, were available from the Caja Agraria for distribution to farmers in 1959. The demand for seed of the variety Monserrate was about three times the quantity available. A total of 1,200 tons of seed was produced in 1959 by the Caja Agraria for distribution to farmers in the first planting season of 1960. However, as a result of a seasonal surplus of potatoes during the latter part of 1959 and the appearance of the brown rot disease of potatoes in the savannah of Bogotá, the demand for seed was reduced to 600 tons. A small part of the excess seed was planted at seed multiplication stations and the remainder was sold on the market for consumption.

This example of varying demand for seed indicates the necessity for adequate refrigerated storage facilities to balance the seasonal fluctuations in supply and demand.

Initial plantings were made in Boyacá and Cauca for the development of seed multiplication programs in these areas. A surplus of potatoes during the latter part of 1959, however, has hindered this plan.

The establishment of efficient seed potato multiplication programs in Colombia is dependent on the availability of adequate storage and marketing facilities for commercial potato producers.

Special Studies

EPIDEMIOLOGY OF LATE BLIGHT

Observations over a five-year period have indicated that the occurrence of late blight can be correlated directly with the amount of rainfall which occurs. Excessively high or low temperatures rarely occur during the growing season and the average daily temperature is optimum for the growth and development of the pathogen.

An infection period for late blight can occur when the ten-day accumulative rainfall is 30.5 mm. or greater. If the average temperature for this period is calculated and applied to a graph indicating the effect of temperature on time of sporulation, the frequency of the periods of late blight development can be predicted. Fungicides to control late blight can be applied at the critical periods of infection, greatly reducing costly applications of fungicides when they are not required.

Another system of timing the application of fungicides to control the late blight disease, based on the amount of rainfall, is presented in the subsequent report of the cooperative investigations of the plant pathology and potato programs.

EFFECT OF TEMPERATURE ON GROWTH AND DEVELOPMENT OF POTATOES

The optimum temperature for foliage formation of the potato has been found to be approximately 20°C., and the optimum air temperature for tuber formation approximately 12°C. If the average monthly day and night temperatures during the growing season are plotted on a graph, the amount of deviation from the optimum will indicate the months more favorable for foliage and tuber development in the potato.

The average monthly day and night temperatures of several areas in Colombia have been plotted on graphs, and there is a correlation between given temperatures and the optimum time for planting and high yield. The optimum date for planting to promote maximum growth and development of the plant is during the months when the average daily temperature is near the optimum of 20°C. The maximum yields are obtained one or two months after a period during which temperatures are optimum for plant development and the average night temperatures are near the 12°C. optimum for tuber development.

By the use of this system, new areas of potato production may be selected, and the optimum time of planting may be determined. Other factors such as soil fertility, rainfall, frost, and varietal adaptation should be considered in the practical application of this information.

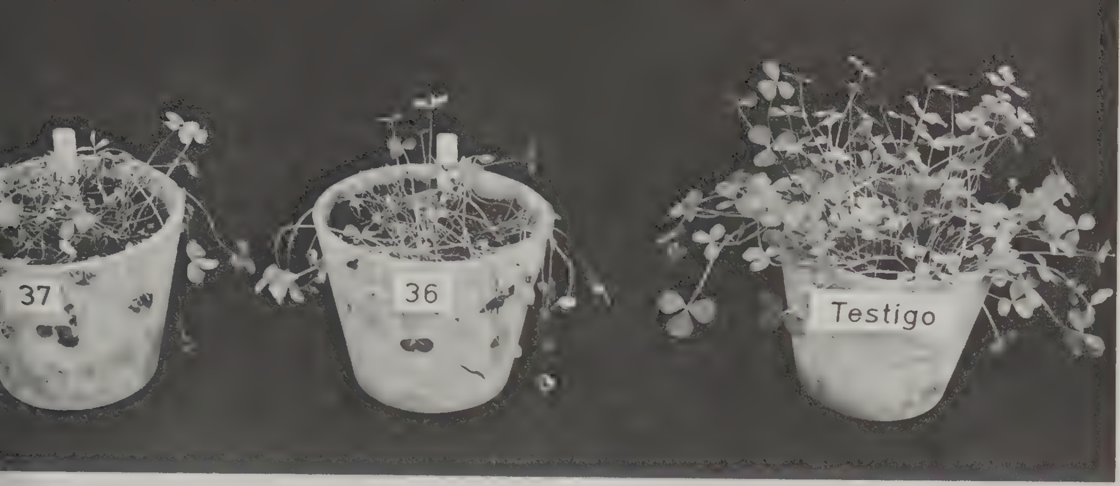
COOPERATIVE STUDIES

Several projects on special disease problems have been undertaken in cooperation with the plant pathology program. These projects are discussed in a following section.

INTERNATIONAL COOPERATION

During 1959, 37 tons of hybrid potato seed from Colombia were sent to Venezuela for regional adaptation trials and seed multiplication. This seed is being used in a cooperative program of potato investigation conducted by the Ministry of Agriculture of Venezuela and the Institute of Agronomy, Maracay, Venezuela.

Small quantities of various Colombian potato hybrids were sent to official organizations in Brazil and Ecuador.



Effect of two isolates of *Sclerotinia sclerotiorum* (36 and 37) on white clover. Uninoculated check plant at right.

Plant Pathology

Most of the work of the plant pathology program is done in cooperation with other programs within DIA. Only major projects in plant pathology are treated in this report; in addition to these, the program has investigated or given advice on disease problems of such crops as beans, tomato, platano, papaya, cotton, and various vegetables.

WHEAT, BARLEY, AND OATS

Since greenhouse facilities have been improved in regard to control of temperature, it has been possible to identify rust races with greater confidence. Fifty per cent of the collections of stem rust of wheat (*Puccinia graminis* var. *tritici*) were identified as race 15B; 7% as race 19; and 43% as other races. Oat rust races (*P. graminis* var. *avenae*) included 3, 4, 6, 7, 7A, 12, 13, and 13A. Preliminary tests with stripe rust of wheat (*P. glumarum*) indicate that its development is strongly influenced not only by temperature, but also by light. In using existing differentials and keys for race identification, it has been found that the rust races present in Colombia are not described in the literature.

Studies on the epidemiology of the rusts, on the influence of the geographical origin of cereal seed on subsequent yield and disease reaction, and on the value of fungicidal seed treatment in protecting cereal plantings were continued during 1959. Three years of cereal seed treatment tests have not demonstrated increased yields.

Two experiments were made with fungicides in 1959 to determine the nature and degree of losses caused by *P. glumarum* and the degree of partial resistance of certain wheat varieties. Valuable and precise data on losses caused by stripe rust were collected. Yield increases of 150% of the untreated check were obtained by using the fungicide zineb. Some varieties, susceptible to *P. glumarum*, exhibited almost no increase in yield, however, when protected with zineb. These results indicate that certain varieties, although exhibiting susceptible pustules, have a high degree of partial resistance under field conditions.

The plant pathology program, in cooperation with the entomology program, has initiated studies of the cereal disease enanismo, which occurs in the state of Nariño. Tests designed to determine whether the causal agent is transmitted by soil, seed, mechanical means, or aphids have given negative results to date. One hundred plants of the wheat variety Bonza, 158 plants of the barley variety

Funza, and 28 plants of the resistant wheat variety Diacol Nariño have been inoculated with single insects of the leafhopper *Cicadulina pastusae* in plastic cages. Forty-one of the barley plants, 26 of the Bonza wheat plants, and none of the Diacol Nariño plants subsequently exhibited symptoms of enanismo. These results strongly indicate that the causal agent of the disease is a virus. Future tests will determine whether this assumption is correct.

DETERIORATION OF STORED GRAIN

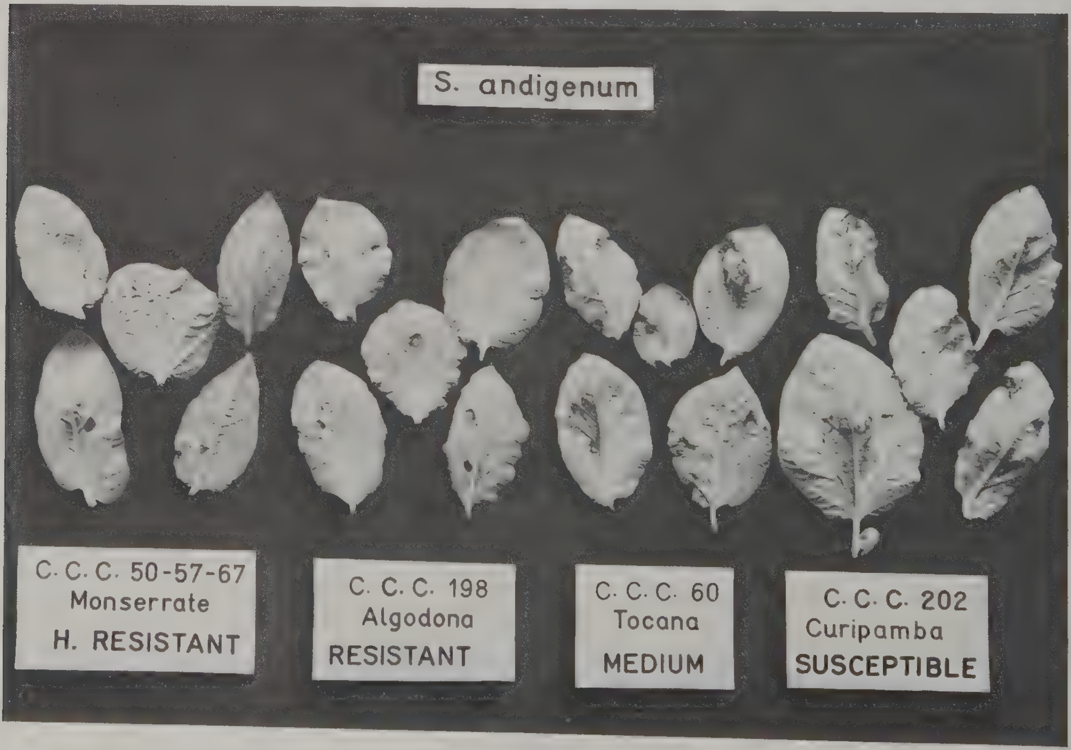
A cooperative project with Dr. Elizabeth Grose, of the University of the Andes, on deterioration of stored grain was begun in August, 1959. Dr. C. M. Christensen, Professor of Plant Pathology, University of Minnesota, spent one month in Colombia as an advisor to the project.

In general, the same species of fungi reported elsewhere have been found to cause deterioration of stored grains in Colombia. Large commercial lots of grain in Colombia are generally stored well, and cognizance is taken of the importance of moisture content in relation to deterioration. Most storage, however, is for relatively short periods of time, because of inadequate storage or drying facilities. This practice makes it difficult for the grower to market his crop when prices are favorable and thus receive a fair return for his efforts. It is hoped that this study will supply basic information on the importance of fungi in deterioration and make possible some improvement in the present situation.

POTATOES

The partial or field resistance of approximately 500 clones of *Solanum tuberosum*, *S. andigenum*, and *S. phureja* to late blight (caused by *Phytophthora infestans*) has been studied in the field. Since 1953, their relative degree of resistance has consistently remained at about the same level. A few clones have

Size of lesions caused by *Phytophthora infestans* on three clones of *Solanum andigenum* and on one highly resistant hybrid.



maintained a very high level of resistance, which the potato program is attempting to utilize; about 20 acres of seedlings from crosses were planted in the field during 1959 to evaluate their resistance to *P. infestans*. In an attempt to develop a more rapid and accurate means than field testing for determining the partial resistance of breeding material, the following studies were made. Three clones of each species were selected, one with a high, one with an intermediate, and one with a low level of partial resistance (as determined by resistance in the field) and tests were made with race O of *P. infestans*. Highly resistant clones required more time to produce sporangia than clones with intermediate or low resistance. Lesions on a clone of *S. andigenum* with low resistance needed five hours to produce sporangia after being placed in a moist chamber, while lesions on a highly resistant clone needed 11 hours. Lesions produced on the highly resistant clones were small in size and produced very few spores as compared with lesions on clones with intermediate and low resistance. Highly resistant clones generally produced fewer lesions than clones with low or intermediate resistance, when all were inoculated with the same sporangial suspension.

These results have been confirmed in duplicate tests. Because some of these measured, simply but precisely, differences in partial resistance, there is good reason to believe that a rapid and accurate greenhouse test can be devised to screen potato breeding material.

A collection of approximately 2,000 clones was planted both semesters of 1959 for evaluation of resistance to late blight. Notes were also taken on the resistance of the collection to the root knot nematode, since a relatively heavy infection by this parasite occurred during one season.

Cooperative Investigations on Potatoes

Several studies have been carried on jointly by the potato and plant pathology sections regarding problems of major importance to both programs.

An important cooperative investigation was the evaluation of the control provided by 14 fungicides for late blight of potatoes caused by *Phytophthora infestans*. The results of tests carried out under weather conditions favorable to the development of the disease, taken together with data collected over the past six years, have enabled DIA to offer growers sound recommendations on efficient and economical fungicide use.

Most potato growers in Colombia apply fungicides without regard to weather conditions or varietal resistance; weekly spraying is a common practice. To determine the optimum frequency of fungicide applications, a test was conducted in which the fungicide maneb was applied to the potato varieties Tuquerreña (highly susceptible) and Monserrate (highly resistant) on two types of schedules, one based on fixed dates of application and the other based on applications after fixed amounts of cumulative rainfall.

The results of this experiment (presented in Table 1) show that the application of the fungicide to the variety Monserrate gave no appreciable increase in yield. Data on the response of the highly susceptible variety Tuquerreña indicate that the application of fungicide after an accumulation of 13 mm. rainfall provided control equal to that given by weekly applications.

These results were obtained during a season of relatively high rainfall. In a dry season, the grower should be able to save considerably more time and money by using a cumulative rainfall spraying schedule.

It must be remembered, however, that these data are based on the results of only one year of experimentation.

BROWN ROT

The occurrence of the disease causing brown rot of potatoes in several plantings of Monserrate near Bogotá has focused attention on the importance of this disease. Although traces of the disease had previously been found at higher altitudes in Colombia, it was believed that the organism would not be a problem because of prevailing low temperatures.

TABLE 1.

Effect of various schedules of maneb applications for control of late blight with the potato varieties, Tuquerreña and Monserrate.

Spraying schedule	Percentage defoliation of Tuquerreña	Yield (ton/ha.)[a]		No. fungicide applications
		Tuquerreña	Monserrate	
Every week	37.0++	29.8	37.1	13
Every two weeks	56.0	25.0	40.8	7
Every three weeks	70.5	20.2	37.1	5
After 6.5 mm. accumulated rainfall	37.0++	29.6	36.7	15
After 13.0 mm. accumulated rainfall	33.0++	28.5	40.7	11
After 19.5 mm. accumulated rainfall	56.0	25.6	38.7	10
After 25.0 mm. accumulated rainfall	63.0	23.2	39.1	8
No treatment	94.0	10.1	36.2	–

[a] L.S.D.—5%—3.4; 1%—4.6.

Preliminary studies on the brown rot organism, *Pseudomonas solanacearum*, have now been initiated to develop methods which can be used in the greenhouse to inoculate and test varieties for resistance to the disease. Varieties with a high degree of resistance to brown rot have been obtained from the United States for use in inoculation studies and as sources of resistance in breeding.

ROOT KNOT NEMATODE

An infestation of root knot nematode, *Heterodera marioni*, developed in an area where potatoes have been planted repeatedly for several years. All plants of the variety Tocana blanca examined during the growing season were found to be heavily infested with nodules in the roots.

To determine whether resistance to root knot nematode existed within the Colombian potato collection, a planting of five tubers each of all varieties in the collection was made in the area where infestation had occurred. Check rows of the susceptible variety Tocana blanca were planted as borders and throughout the planting. When a heavy infestation of the roots of the check variety developed, all plants were harvested and the occurrence of the disease observed.

While all roots of the check variety were heavily infested, many of the clones of *Solanum andigenum* and *S. phureja* were completely free of infection. Although the results of this observational trial cannot be considered conclusive, it does appear that many native varieties have a high degree of resistance to the root knot nematode.

CORN

Routine tests of the resistance of corn lines to stalk and ear rots caused by *Diplodia zeae* and species of *Fusarium* were made at Palmira and Tulio Ospina. Tests on the resistance of elite lines of corn to attack by *Helminthosporium turcicum* were continued at Tulio Ospina.

The plant pathology program terminated an experiment begun in 1958 on the effectiveness of treating corn seed with fungicides to improve field and storage performance in the hot, humid climate of Montería. Several of the 14 fungicides tested gave excellent protection of seed which was planted in the field after three or six months of storage; after nine months of storage, however, all treated seed of the four corn lines used in the test had 0% germination. Subsequent studies have shown that the initial moisture content of the seed has a most important effect on subsequent deterioration by storage fungi. When moisture content was high, none of the fungicides tested were able to prevent storage fungi from killing stored seed.

FORAGE CROPS

The major subject of research by the pathologist at Tulio Ospina is the disease gummosis of Imperial and micay grasses caused by the bacterium *Xanthomonas axonoperis*. Over 100 collections of these grasses, made throughout Colombia, have been tested by laboratory inoculations and although no collection has been found to be completely resistant in the laboratory a number of the same collections have maintained a high degree of partial resistance when planted in the field. The resistant material will be increased, in cooperation with the forage program, for release to growers. A newly developed method of inoculation, using a suspension of bacteria under a vacuum, has increased the percentage of plants infected and reduced the time necessary for observation of symptoms from 60 to as few as 15 days.

A plant pathologist was added to the staff in September, 1959, to work full time on cool climate forage crops. A survey of the occurrence and importance of diseases of these forages is well under way. The most serious

Corn stored at Medellín 100% infected with *Aspergillus restrictus*.

problem of the forage program at Tibaitatá is a root and stem rot complex of white clover. It has been proven that *Sclerotinia sclerotiorum*, *Rhizoctonia solani*, and *Botrytis* sp., of a large number of fungi isolated from diseased material, are capable of causing symptoms similar to those seen in the field. Methods have been devised and are being used for testing white clover lines which have been developed by the forage program.

RICE

The plant pathologist at Palmira is working on the most important disease of rice in Colombia, hoja blanca. Tests made during the past year at Palmira confirmed previous data showing that the causal agent of hoja blanca is not transmitted by soil, seed, or mechanical means. One vector of the disease is the leafhopper *Sogata orizicola;* of 1,035 insects of this species which have been tested individually, 9% have transmitted the disease. A previously unreported vector, the leafhopper *Sogata cubana*, has been found. Twenty-four successful transmissions have been made with this insect from rice to *Echinochloa colonum* or from *E. colonum* to *E. colonum*. No successful transmissions have been made from rice to rice or from *E. colonum* to rice. Using *S. orizicola*, it has been possible to transmit the virus from rice to rice and from rice to *E. colonum*, but not from *E. colonum* to *E. colonum* or from *E. colonum* to rice.

Certain grass weeds with symptoms of hoja blanca have been found in the field. Under controlled conditions, the following grasses and cereals have been successfully inoculated, by means of insect vectors, with the virus causing hoja blanca: (1) rice—*Oryza sativa;* (2) wheat—*Triticum vulgare;* (3) barley—*Hordeum vulgare;* (4) oats—*Avena sativa;* (5) *Echinochloa colonum;* (6) *Digitaria horizontalis;* (7) *Leptochloa filiformis*. In a number of other grasses and cereals tested, no disease symptoms of hoja blanca appeared.

The low percentage of the field population of *S. orizicola* shown to transmit the hoja blanca disease raises interesting questions. These are under investigation.

SUGAR CANE

At the request of the sugar-cane program of DIA, a test was made in Palmira to determine whether the virus which causes "ratoon stunting disease" occurs in Colombia. Seed pieces (sections of sugar-cane stems) were treated with hot water at 51° C. for two hours and compared with others without treatment. The differences between treated and non-treated "seed" were striking. The size, color, and known disease symptoms observed in the plots planted with non-treated "seed" indicate that the ratoon stunting disease probably exists in Colombia. Judging by what is known of the disease as it occurs in other countries, it may be causing important losses.

Effect of borax on alfalfa.

Soil Science

Field, greenhouse, and laboratory experiments are being carried out by the soils section with the over-all aim of achieving and maintaining high levels of crop productivity. Projects are grouped under four general headings: (1) studies of the efficient use of fertilizer; (2) evaluation of long-term effects of crop management practices on soil productivity; (3) characterization of soil properties in relation to productivity; (4) soil-water-plant relationships.

Initial emphasis has been placed on studies in the use of fertilizer and on crop management, and considerable progress has been made in obtaining data on which to base general recommendations concerning these subjects. The results of studies are brought to the attention of agronomists and farmers by the publication of technical bulletins, some of which have appeared during the past year and some of which are soon to be issued.

As the project advances, emphasis is being increased on studies of soil properties in relation to productivity. In these studies, data of a more basic nature will be sought, with the purpose of increasing the efficiency of predictions of crop responses. Several new projects in this category are outlined in subsequent sections of this report.

Experiments on soil-water-plant relationships have been undertaken more recently, and an increase of emphasis in this area is anticipated. A great part of the land area of Colombia has a temperature regime which will allow a 12-month growing season. A factor which prevents fullest realization of this potential is rainfall, which is usually inadequate for optimum production during at least part of the year. This limitation becomes more important as other practices are improved.

THE EFFICIENT USE OF FERTILIZERS

Several experiments on nitrogen and phosphorus fertilization of wheat were conducted on private farms in the savannah of Bogotá. Yields of wheat varied greatly from one location to another. Although responses were obtained to both nitrogen and phosphorus, the data indicate that other soil factors, in some instances, placed a low ceiling on yield. Laboratory and greenhouse data suggest that soil acidity may have been of importance. Increasing pH from 4.6 to 6.0 resulted in a 230% increase in yield of an indicator crop on one of these soils. Further data on the relationship of soil reaction to wheat yields are needed, since definite depressing effects have been encountered at Tibaitatá when pH was adjusted from 5.3 to 5.8.

Great beneficial effects were measured after the use of lime, phosphorus, and boron on alfalfa planted on the red latosolic soils which occur in the higher areas on the margins of the Cauca Valley. These soils differ notably from the majority of those of the Cauca Valley in that they are acid and highly leached, while the others are nearly neutral or alkaline in reaction. Lime and phosphorus applications resulted in about doubling of yield at the first cutting. Without boron applications, it was not possible to establish alfalfa, and yields were zero. Similar results have been reported earlier for the alkaline soils of the region. Experience in various parts of the world has shown that, in general, boron deficiency occurs in alkaline soils where boron availability is low or, at the other extreme, in acid soils with a low total supply of boron. It is not uncommon to find, however, that highly leached latosols still contain sufficient boron for crop production. Thus, the possibility exists that these instances of boron deficiency are basically due to a low level of boron-containing minerals in the parent materials from which these soils were derived. Evaluation of this possibility could lead to a basis for predicting broad general regions of poor boron supply.

Experiments with the use of lime and phosphorus on corn and beans at Popayán also produced large yield increases. The response of corn to lime amounted to 1.34 tons of grain per hectare. The severe magnesium deficiency reported from earlier work at this location was not found in 1959. Apparently the soil on the experimental farm is quite variable in this respect. However, the general picture of severe phosphorus deficiency and the complex of acid soil effects appears clear.

LONG-TERM MANAGEMENT PRACTICES

Evaluation of cropping systems is a slow and laborious process. The effect of any one crop on soil properties is often small, and only after several years does the cumulative effect, either harmful or beneficial, become evident. For this reason such experiments can be located on relatively few soil types. Experiments have been under way for about four years, however, in several climatic zones. The programs involving potatoes, wheat, and pasture seem most suitable for the higher altitudes. In the warm climate, rotations of corn with legumes such as alfalfa and soybeans are being studied.

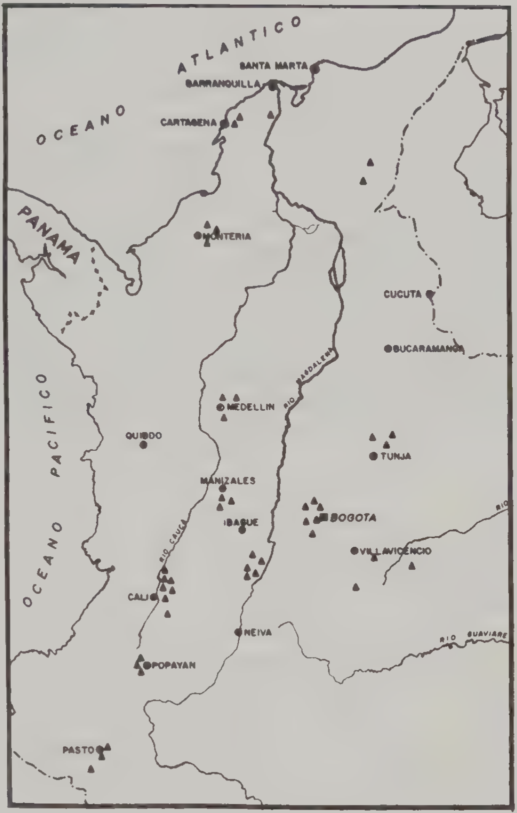
Useful information concerning soil reserves of plant nutrients can be obtained from continuous cropping experiments. Responses to nitrogen and phosphorus have frequently been obtained after short periods of cropping, but results indicate sizable reserves in some of the better soils. Such investigations have shown some interesting contrasts between species, as well as between soil types. At Tibaitatá, potatoes were planted for seven consecutive crops with no differences in yield due to liming or fertilization with N, P, and K. In the eighth crop, a difference due to phosphorus was measured. The apparent ability of the soil at this location to support potato production for so long a period without response to N, P, or K was rather unexpected, for this crop normally is very responsive to fertilizer. Further analysis of this situation should be of interest.

Similar results have been obtained with four consecutive crops of corn. Wheat and barley, on the other hand, have responded to phosphorus particularly, but also to nitrogen, after two crops. When well fertilized, wheat has maintained good yields but there has been a continued downward trend in barley under the monoculture program. At Palmira, in the Cauca Valley, corn has been grown continuously for nine crops with differential rates of N, P, and K. Through the ninth crop, there have been no significant differences in yield. Yields have been poorer in most seasons than they were initially, but there is no indication that nutrient depletion is responsible. In the ninth crop, yields were in the range of 5 to 6 tons per hectare.

LABORATORY AND GREENHOUSE STUDIES

Comparative studies of a number of laboratory procedures for measuring phosphorus and potash supplies of soils have been initiated. For these experiments, a total of 46 bulk samples of important soil types were collected from all over the country. Greenhouse experiments were established to measure plant uptake of the two nutrients and to determine the effect of the added nutrients on yield. Since previous field experiments had indicated that deficiencies of phosphorus were widespread and usually appeared without prolonged cropping, a fast-growing indicator plant, barley, was used as the test plant to evaluate relative phosphorus status. Previous results have suggested that potassium, on the other hand, is usually present in sufficient supply to allow at least one or two crops to be harvested before deficiencies occur. Consequently, emphasis in the potassium study was placed on continued intensive cropping intended to gauge potassium reserves of the soils under observation, and a perennial, Ladino clover, was used as the test crop. In both instances, laboratory phases of the study consist of comparing a number of extraction procedures with these crop response data. Field experiments and additional greenhouse work may be undertaken as these studies develop.

Yields without added phosphorus were less than 40% of yields with phosphorus, for about half of the soils tested. A yield reduction of this magnitude with this crop suggests a low phosphorus status with a possibility of field response. As was predicted, differences in growth of clover as a result of potassium additions have been much less common. By the fourth cutting, however, several soils gave evidence of potassium stress.



Sampling sites of soils used in laboratory and greenhouse experiments on the phosphorus and potassium status of Colombian soils.

SOIL-PLANT-WATER RELATIONSHIPS

Three fertilizer-irrigation experiments with potatoes were completed at Tibaitatá during 1959. In two of these, no significant differences due to irrigation were measured; in the third, however, yield was increased by about one-third. The rainfall pattern in this region is such that economic evaluation of irrigation practices will require continued experimentation and careful analysis of meteorological data. Emphasis on studies of this type will be considerably increased during the coming year.

Measurements of evapotranspiration water losses of several crops are being made at Palmira. This work has been carried out by the meteorology section, which became a part of the soils program about a year ago. Data of this sort will be useful in predicting irrigation needs in the Cauca Valley. Similar data will be collected in other climatic zones, as a part of future work on soil-plant-water relationships.

Newly seeded sward of English ryegrass, orchardgrass, and white and red clover.

Pasture and Forage Crops

With the initiation of pasture and forage crops investigation at two new experiment stations in the warm climate, studies are now being carried out in areas ranging in altitude from sea level to 10,000 feet.

At several of the smaller stations, the investigations of both the soils and forage programs, which include many experiments of mutual interest, are supervised by a single Colombian agronomist. Through this coordinated effort, greater efficiency of administration is obtained.

Other experiments are conducted in cooperation with the animal husbandry, plant pathology, entomology, cereals, and statistics programs. In some instances, one man is charged with the operation of an experiment, and consults with a member of the other program involved; sometimes men from two programs equally share responsibility for the study. In the following discussion, the various aspects of pasture and forage crops investigation have been separated into subject matter dealing with related topics.

INTRODUCTION NURSERIES

Introduction gardens are maintained at several locations for the screening of new grass and legume species and varieties. These nurseries are useful for showing to visitors and, at Palmira and Tulio Ospina, are used by agronomy students. The observations and related varietal trials have made it possible to make concrete recommendations to the Ministry of Agriculture relative to seed importations, and to the National Seed Increase Committee concerning the propagation of seed stocks. This committee has established five centers for the increase of seeds and vegetative material of certain grasses. The following grasses were turned over to the director of this organization for increase and release to farmers: pangola, coastal bermuda, dwarf type guinea, forage sorghum, sudan, and a selection of Guatemala and Merker elephant.

The collection of the dwarf guineagrasses from Venezuela, Australia, Africa, and Puerto Rico is of particular interest. The plants are much smaller than the common guineagrass and have shorter internodes, finer stems and leaves, and reduced panicle size. Although forage production does not equal that of the taller-growing type, plant growth is more rapid and average yields of up to 2.0 tons of dry hay have been harvested at intervals of four weeks. Having more leaves, the forage contains more protein than the common forms. Seed production is good, but germination may be as low as 5% (equivalent to the common). Nevertheless, adequate stands may be obtained by planting in rows or broadcasting on a prepared seedbed.

GRASS AND LEGUME BREEDING

RYEGRASS

The ryegrass improvement program includes an evaluation of a number of procedures: (1) mass selection; (2) polycross progeny testing; (3) reciprocal recurrent selection; (4) testing of selfed progeny. The same genotypes are being utilized for all methods, and progeny studies are presently under way.

Seeds of an improved variety of *Lolium multiflorum* are being increased and will be turned over to the National Seed Committee for volume output to farmers. The variety was developed by recombining 200 superior clones which were selected from single plants. The criteria used for selection were tiller formation, leafiness, forage production, seed formation, rust resistance, rapidity of recuperation after harvest, and plant longevity. Phenotypically, the parental plants resemble annual (Italian) ryegrass, but have persisted for more than three years.

WHITE CLOVER

From a nursery of 10,000 single plants, 20 superior clones were chosen for the following types: (1) Ladino with less than three floral heads per square foot; (2) Ladino with 10 to 20 seed heads per square foot; (3) intermediate white with many flowers and persistent plants; and (4) intermediate white with many flowers and plants which did not perenniate. The plants within each type were isolated in replicated blocks and allowed to intercross. Seeds of each plant were harvested and planted for evaluation in a replicated progeny test. Data from this study have shown increased forage yield and uniformity of flowering in the selected material. Furthermore, the more persistent parental plants had more persistent progeny and those with poor longevity had progeny with low persistence.

Plant longevity appears to be directly related to stolon disease, soil moisture conditions, and flower formation. Studies conducted by members of the plant pathology program have shown that the following organisms may attack the stolons: *Sclerotinia sclerotiorum*, *Rhizoctonia solani*, and *Botrytis* sp. Cooperative studies have been initiated to investigate the specificity of these diseases and to determine whether resistance to *Sclerotinia* exists.

The plants which flower abundantly appear to be most susceptible to the disease complex under field conditions. The dry season begins at the time of peak flowering, a period during which the plants are weakened physiologically. Foliar development is thus reduced and the stolons tend to lose turgidity and become flaccid. The expression of the disease becomes most evident during this phase of the syndrome and many stolons are killed.

RED CLOVER

In the evaluation of single plants of red clover, it became evident that the expression of growth type did not change from one season to the next. Since this was so, phenotypes could be precisely classified into the following categories: (1) rosette, no flowering stems; (2) pronounced rosette, few or no floral stems, no seed or poor seed formation; (3) distinct rosette, few to many semi-erect floral stems, few to many flowers, seed formation fair but not uniform in maturity; (4) inconspicuous rosette, many semi-erect and erect floral stems, many seed heads, good seed set but not too uniform in maturity; (5) no rosette, many erect floral stems, many seed heads, good seed set, and rather uniform in maturity.

Furthermore, varieties were characterized by a constant percentage of growth types. As indicated by the data in Table 1, the plants of Alaskland, a variety developed above 60° latitude, did not form floral stems; varieties which originated between 45° and 50° latitude (or seeds of which were grown for several generations in this area) had a greater per-

TABLE 1.
Flowering and plant growth types of red clover varieties in plantings at Bogotá.

Variety	Where grown	Percent flowering	Percent in growth type[a] 1	2	3	4	5
Alaskland	Washington	0	100	–	–	–	–
Craig	Pennsylvania	10	45	43	10	2	–
Midland	Nebraska	25	14	61	15	8	2
Kenland	California	55	2	24	57	13	2
Nolins	Louisiana	90	–	–	9	10	81
Local	Colombia	100	–	–	–	15	85

[a] Growth types are defined on page 151.

centage of types 1 and 2; varieties from between 37° and 42° latitude generally had plants of all growth types, but included a higher proportion of types 2 and 3; varieties from 30° to 33° showed a preponderance of types 4 and 5; a selection of local Colombian varieties had a greater percentage of type 5. Thus, under the 12½-hour day length at the high elevations in Colombia, the classification of red clover varieties was specifically related to latitude and the photoperiod under which the selection was made. When placed under an extended day length of 18 hours, plants of all types flowered abundantly.

These data are valuable in the breeding program from the point of view of promoting forage quality, seed production, and plant longevity. The forage produced by plants of types 1, 2, and 3 is more leafy and of superior quality; plants of types 4 and 5 are heaviest seed producers, but are less persistent.

BIRDSFOOT TREFOIL

The results of varietal trials indicate that birdsfoot trefoil is the most drought-tolerant legume that has been studied in the cool climate of Colombia. Forage yields, however, have not totaled more than 1,000 pounds of dry hay in one year. During the past year, a Brazilian selection which produced more forage and had some flowers was obtained. It has been observed from single plant studies that about 10% develop flowers and form seeds. As the seeds appear, they are harvested by hand. These will be used in a recurrent cycle of mass selection for flowering types. It is anticipated that in this way lines can be selected which will yield more tonnage of forage and produce high-quality seed.

FORAGE SORGHUM AND SUDANGRASS

A number of inbred lines and varieties of forage sorghum and Sudangrass were seeded for continued inbreeding, and it is anticipated that material with resistance to rust (*Puccinia purpurea*) can be developed.

Several selections of *Sorghum almum* were included for development of inbred lines. This species does not yield as much forage as the forage sorghum and Sudan, but it may be cut or grazed at an earlier stage of growth without damaging the stand. The plants tiller freely and develop short rhizomes which are easily destroyed. All of the material examined has been highly heterogeneous and should be easily modified for uniformity in plant growth, seed maturity, and disease tolerance.

A number of F_3 lines of forage sorghum were composited for limited seed increase at the Palmira, Nataima, and Turipaná experiment stations. These will be released in small quantities to farmers who solicit seed directly

Plants of red clover varieties from Alaska did not develop floral stems while those of varieties from the United States did, under the short day (12½ hours) in Colombia.

from the stations and for plantings to supply the green chopped forage and silage needs of the animal husbandry program.

IMPERIAL AND MICAY GRASSES

A technique has been perfected by the plant pathology program for inoculating plants with bacteria which cause gummosis of Imperial grass, an important green crop forage grass, and of micay, a pasture grass. The disease gummosis, which results in dwarfing and suppresses new tiller formation, has eliminated many plantings. Since the grasses are propagated vegetatively, the first screening phase has involved the use of clonal material collected from commercial fields. Although all the selections were susceptible when inoculated in the greenhouse, seven clones have shown field resistance and are being increased for regional tests.

The screening of seedlings had been planned as the second phase of the improvement program. Seeds were produced in large quantities, but germination was low, ranging from 0 to 20%. Furthermore, the seedlings did not grow normally and after three months had developed only two or three leaves. It thus appeared that this approach would have to be abandoned. During the collecting trips, however, it was observed that plants of Imperial grass occurred on the roadside cuts immediately below a planting. On closer examination, seedlings and plants of various sizes were found. It is assumed, therefore, that initial plant growth is extremely slow and several months may be required for development. Additional studies have been initiated, in which seedlings will be grown under different conditions. The region in which collections have been made will be resampled and only the young plants removed for use in the screening evaluations.

PASTURE MANAGEMENT

Experiments have been designed to study the following aspects of pasture management:

(1) land preparation; (2) rates and methods of seeding; (3) response to various fertilizer elements applied in differing amounts; (4) grass-legume mixtures; (5) height and frequency of cutting; (6) weed control; (7) irrigation; (8) root growth; (9) rotations; (10) renovation of old pastures. Many of these experiments have been terminated and the data resulting from them published in *Agricultura Tropical*, the official journal of the Colombian Society of Agronomy. Bulletins covering the broader scope of pasture development are also being prepared. Some trials related to pasture management are being continued, and others have been redesigned to evaluate certain points more fully and in greater detail. In future projects, particular emphasis will be placed on problems concerning seed production.

ROOT GROWTH

A study of the root development in grasses showed the following sequence in total production per unit area in the top 20 cm. layer of soil: micay, guinea, Imperial, pangola, and elephant. This order changed slightly in the 20 to 50 cm. layer (as indicated in the data in Table 2). The most extensive root system was developed by micay, a low-growing, extending perennial which produces forage yields far below those of the other grasses included in the study. The greatest amount of forage, in fact, is produced by elephantgrass, which has the lowest root growth. It is possible that a higher percentage of the roots of such bunch-type grasses are found directly under the plant and thus were not sampled. Pangola, however, extends by stolons and has less roots than guinea and Imperial, which are bunch types. The pattern of root development is undoubtedly a characteristic of the species and is related to efficiency of the conversion of photosynthetic products into aerial growth as contrasted to root formation. There are no latent periods in the plant growth cycle in Colombia and, as a consequence, there is little opportunity for the accumulation of root reserves.

Applications of nitrogen resulted in a slight increase in root production; addition of phosphorus and potassium did not affect root development.

CHEMICAL COMPOSITION OF FORAGES

The soils and chemistry laboratory has made protein analyses of some grasses and legumes (see Table 3). Variation proved to be greater among intervals of harvest than among species. The forages had a higher protein content when the grasses were cut more frequently. In general, however, while the percentage of protein diminished as the plants became more mature, forage yields were increased with prolonged harvest. To obtain higher quality, therefore, total production must be reduced to some extent. Certain practices, such as irrigation and proper fertilization, help maintain production and may not greatly alter protein content.

COOPERATIVE INVESTIGATIONS OF SOILS AND FORAGE CROPS PROGRAMS

Cooperative investigations related to pasture fertilization were again conducted during

TABLE 2.

Root development in five grasses at two soil layers.

Depth of sample	Root weight (mg.) per core of soil				
	Micay	Guinea	Imperial	Pangola	Elephant
0–20 cm.	29.5	19.5	19.0	15.4	15.1
20–50 cm.	7.5	6.5	6.0	5.4	4.2

TABLE 3.

Effect of frequency of cutting on percentage of protein in grass forage.

	Percentage of protein at:		
Grass	4 wks.	8 wks.	12 wks.
Coastal	11.03	8.75	5.60
Pangola	10.50	9.45	3.41
Elephant	10.85	7.26	3.41
Guinea	10.06	9.28	3.76
Sorghum	16.45	8.14	4.11

1959 by the soils and forage crops programs. Approximately 75 experiments involving 22 soil types were held. Greenhouse and field trials were concerned with the response of grasses and legumes to applications of nitrogen, phosphorus, potassium, boron and other minor elements, and lime (N, P, K, B, and Ca). Studies also involved such factors as method, rate, and time of fertilizer applications; soil management practices; soil-water relationships; plant competition for soil nutrients; pasture renovation; and farming systems (rotations). The following discussion is limited to some of the more pertinent results which have been obtained.

CROPS-PASTURE ROTATIONS

The potato and cereal crops in Colombia are usually heavily and moderately fertilized, respectively. Experimental data have shown that optimum yields are obtained with quantities of fertilizer elements in excess of those removed in the harvest. Thus, a reserve of nutrients accumulates in the soil. Generally, pastures are not fertilized and output is low.

A crop sequence of potatoes, wheat, and pastures has been studied in several cool climate locations for four years. Data have shown that after potato harvest, a minimum effort was required to prepare land for sowing wheat in the second semester. Furthermore, an excellent stand of grasses and legumes (ryegrass and white clover or orchardgrass and red clover) was obtained when these crops were seeded at the same time as the cereal crop, provided soil moisture was favorable. Weeds were controlled with a pre-emergence application of an herbicide. The pasture mixture did not interfere with the cereal grain harvest or reduce grain yields.

The results of these studies demonstrated that the following amounts of fertilizer elements were sufficient for one crop of potatoes, one wheat harvest, and one year of pasture production: 200 kg. of P_2O_5 per hectare and 50 kg. of K_2O applied only to potatoes, 100 kg. of N to the potatoes and 50 kg. to the wheat. No N was needed for the pasture crops when clover made up 45% to 50% of the mixture. Lime at the rate of 5.0 tons per hectare was applied before planting the potatoes. Although the lime was not needed by the potato crop, it did not alter production and was beneficial to the clovers. Judging from results of other experiments, the pasture production could be maintained for an additional one or two years without additional fertilizer.

The incorporation of a pasture crop in the rotation also provided additional profit, as shown by the data in Table 4.

Other rotations under study include the following crop sequences: (1) potatoes-oats; (2) potatoes-wheat-pangola grass; (3) corn-soybean-alfalfa; (4) rice-field crops-pastures. The results of these trials also show that the pasture crops do not require additional fertilizer for optimum growth.

ALFALFA FERTILIZATION

A five-year resumé of alfalfa fertility requirements has shown that a number of soil types are not well adapted to alfalfa production. In some instances, the soil can be altered by drainage, by the use of lime to correct acidity, by heavy dosages of P, and, in some cases, by applications of borax. In badly eroded soils or in those with a very shallow "hard pan," the cultivation of alfalfa is probably not advisable.

Soils at high altitudes (5,000 to 9,000 feet above sea level) are generally acid (pH of 4.5 to 5.5), high in organic matter (8% to 20%),

TABLE 4.

Estimated cost, yield, and profit of a two-year rotation of potatoes, wheat, and pasture.

Crop	Yield (ton/ha.)	Cost[a]	Value[a]	Profit[a]	Profit[a] with continuous cropping[b]
Potatoes	25.0	868	1,000	132	528
Wheat	2.0	176	257	81	325
Pasture	12.5	74[c]	536	461	–

[a] Expressed in U. S. dollars, calculated at exchange of 7 pesos for 1 dollar.

[b] Summation of four harvests.

[c] Cost of pasture production includes lime, seed, planting, herbicide, and harvesting.

very low in P, and medium in K. It has been demonstrated that alfalfa could best be established in such soils by first growing potatoes and wheat for several semesters. In this way, the fertility status was adjusted to the needs of alfalfa. For maintenance of optimum production, the following annual top-dressings were also required: 50 kg. of P_2O_5 per hectare and 100 kg. of K_2O. Additional lime and borax may also be necessary, depending on the soil type. Several experimental plantings have been cut at six- to eight-week intervals for five years, with an average production of 2.3 tons of hay per hectare. Production and frequency of harvest varied with available soil moisture.

In the warm climate at lower altitudes (2,000 to 5,000 feet above sea level), the soils are less acid (pH 5.6 to 7.0), lower in organic matter, and generally higher in P and K; more soil types, however, are deficient in boron. In general, applications of lime, P, and K have given no response. In contrast, the success or failure of alfalfa has depended on borax in some locations, as illustrated by the data in Table 5.

GRASS FERTILIZATION

The warm season and subtropical grasses have not responded to applications of Ca, P, and K on most soil types. A slightly higher yield did occur when P was applied to elephantgrass on a highly organic soil at Popayán and on a recent colluvial red clay soil at Medellín. The yields of most grasses have been increased significantly by the use of N. In many instances, the application of 100 kg. of N per hectare after each harvest resulted in 10 to 15 times as much forage as was produced by the check.

The data in Table 6 show that production of Imperial grass was severely impaired by applications of nitrate of soda on a red clay soil at Medellín.

The source of N used resulted in a drastic change in soil pH. Since the soil complex of this particular series has a very low buffer capacity, high quantities of free aluminum

TABLE 5.

Effect of borax applications on alfalfa yields at three locations.

Borax (kg./ha.)	Yield (kg./ha.) of alfalfa hay at:		
	Palmira	Bolo	Rozo
0	650	960	2,755
25	1,850	2,180	2,700
50	2,130	2,160	2,800
100	2,300	2,410	2,685

TABLE 6.

Effect of applications of nitrate of soda on yields of Imperial grass and on soil.

Nitrogen applied (kg./ha.)	Hay yield, 10th cut (kg./ha.)	Soil pH
0	4,985	5.85
50	2,455	5.30
100	695	5.07
200	315	4.50

and iron were released. Imperial grass apparently cannot tolerate free ions of these elements. Other grasses which were treated identically on the same soil have not been adversely affected.

NEW PROJECTS

Investigations in soils and forage crops were initiated at two hot-climate stations, one near El Espinal in the upper Magdalena Valley (1,200 feet above sea level) and one at Cereté, in the Sinú Valley (150 feet above sea level). A Colombian agronomist has been assigned to each station and will be responsible for studies in both programs. The work at these stations will be directed toward species adaptation, rotational and management practices, grass-legume mixtures, and the investigation of the responses of various crops to fertilization and irrigation.

The bean pod borer, *Ephestia cautella* (Walk.).

Entomology

Insects cause great damage to both crops and livestock in Colombia and the objective of the entomology program is to find practical methods by which these losses of foodstuff can be prevented. To this end, entomologists are at work at all the major experiment stations. In addition to carrying on the research reported here, entomologists in the program have continued cooperation with the fields of agricultural extension and education and have published a series of technical papers on their work.

IDENTIFICATION AND BIOLOGIES OF PESTS

The collection and identification of pests in Colombia has been well advanced during the past year. Forty-five shipments of specimens involving 65 families of insects were sent out to specialists for identification, and several new species were found among this material. The screw worms *Callitroga macellaria* (Fab.) and *C. hominivorax* (Coq.), which are pests of livestock in the United States, were among the pests from Colombia that have already been identified.

A study of the variation in populations of the weevils so damaging to stored grains has shown that a complex of species of the genus *Sitophilus* is involved. The species of this complex vary in their response to control measures as well as in their morphology. Similarly, three species of fulgorids were found to be common in rice affected with the disease hoja blanca. These insects were identified as *Sogata orizicola* Muir, *S. cubana* (Crawf.), and *Chloriona* (*Sogatella*) *furcifera* (Hova.). Methods for the rapid identification and separation of these fulgorids were developed for use in the study of these insects as vectors of hoja blanca.

Studies of the biologies of some pests were continued during the year. The study of the leafhopper *Cicadulina pastusae* Rup. and DeL., associated with the disease enanismo of barley, has been largely completed.

It was observed that the eggs of this pest are laid along the central vein of the young leaves of barley, and that these leafhoppers are attacked by unidentified parasites of the family *Pipunculidae*. While the duration of the various stages of development of *C. pastusae* are strongly influenced by climatic factors, the approximate durations of the stages can be calculated as 20 days for egg, 30 days for nymph, and 20 days for adult.

CHEMICAL CONTROL STUDIES

The greater portion of the work of the entomology program during the past year has been in the development of insecticidal controls of pests. It was found that three early applications of the insecticides demeton, parathion, endrin, or toxophene would reduce the populations of insects in rice that was subject to infection with hoja blanca and significantly increase the yield of the crop. Similarly, barley was protected from the disease enanismo and the leafhopper *Cicadulina pastusae* by early applications of DDT, demeton, or parathion, while similar applications of aldrin, endrin, and heptachlor were ineffectual.

In tests for the control of the leafhopper *Empoasca kraemeri* R. and M., Sevin, Shell WL 1650, and Ethion were found to be as effective as DDT, endrin, and parathion, which are currently recommended for the control of this pest. Parathion showed promise for the control of the bean leaf miner, *Agromyza* sp., which is a pest of beans in the cooler regions of Colombia. Shell WL 1650 gave good control of this leaf miner in beans, the leaf miners *Liriomyza* sp. and *Gnorimoschema* sp. of potatoes, and also of the fall armyworm, *Laphygma frugiperda* (S.) in corn, but the insecticide was phytotoxic to the crops. The damage to the plant caused by application of this material is done by the insecticide itself and not by the spray adjuvant.

In tests of protectants of stored grains, sprays of malathion proved to be better than equivalent sprays of Pyrenone for the protection of stored corn and beans. Malathion, Diazinon, and methoxychlor continued to give good control in dairy barns of the bothersome house fly, *Musca domestica* L.

RESISTANCE OF CROPS TO PESTS

Work has been continued during the year on the important subject of resistance of crops to their insect pests. The results obtained were variable, and practical results from this work must await further studies. Flea beetles, principally of the genus *Epitrix*, were common in the Valley of Paipa and a few potato hybrids were found to be resistant to these pests.

BIOLOGICAL CONTROL

Studies were initiated this year in the use of pathogens against the fall armyworm, *Laphygma frugiperda* (S.) of corn. The bacterium *Bacillus thuringiensis* Ber. proved to be equal to a toxaphene bait (a standard insecticide treatment for the worms) in controlling this armyworm. The fungus *Beauveria bassiana* (Bals.) Vuill. was not as effective as the bacterium against the pest. Two other pathogenic species of fungi and one other species of bacterium are currently being investigated for use against *L. frugiperda*.

SPECIAL STUDIES

The studies of weed killers during the year were restricted to the investigation of chemicals for the control of nut grass, *Cyperus* sp., in the warmer areas of the country. Mixtures of either DNBP or PCP with aminotriazol showed some promise for this purpose. Applications of CMU for the control of these weeds showed marked residual phytotoxicity to beans but not to corn.

In studies of the association of the leafhopper *Cicadulina pastusae* with the disease enanismo of wheat and barley, it was found that 25% to 30% of the insects were capable of producing symptoms on the plants. The first symptoms appeared about eight days after exposure to the insects. The symptoms expressed varied with the different varieties of wheat and barley. Wheat showed many more swellings of the veins (galls) than did barley, while barley was more frequently stunted than wheat. In some cases, a single insect produced symptoms of enanismo in plants of the susceptible barley variety Funza.

Romney Marsh lambs at Tibaitatá.

Animal Science

BEEF CATTLE

Beef has improved in quality in Colombia, and continues to be the main source of animal protein in human nutrition for consumers at all income levels. Although the volume of production is still low, higher-quality beef is being produced for local sale and consumption, and with the strong possibility of an export market, the production of large volumes of high-quality beef is increasing. Breeding herds of both purebred and grade animals have improved in quality, and in general, beef cattle still represent the most important animal industry in Colombia.

Studies were conducted by the beef cattle program at five experiment stations during the past year. Breeding and selection of the existing herds was continued at Tibaitatá, Montería, Cereté, Armero, and La Libertad. At Tibaitatá, Angus cattle are being studied; at Montería-Cereté, the Romosinuano, an outstanding native beef breed is being tested; at Armero, both Cebú and Romosinuano herds are maintained; at La Libertad, the Sanmartinero, another native beef breed, is under observation. During the period covered by this report, steer-fattening trials were initiated at Palmira, Montería-Cereté, and La Libertad.

Feed-lot fattening, the use of grains, silages, improved pastures, and hormones for fattening of steers are also receiving attention from the beef cattle program.

EXPERIMENT STATION DEVELOPMENT

The outstanding developments in the beef cattle program during the past year were the initiation of work at La Libertad in the Llanos; the actual opening of the beef cattle section at Palmira and the start of a grazing experiment there; and the expansion of work at Cereté.

Although the development of facilities has been continued at the five beef cattle research centers, the limiting factor in the successful evolution of the beef cattle program continues to be the lack of facilities, both pastures and barns, at all stations.

PERSONNEL

During the past year, five animal husbandmen were added to the staff, making a total of eight men working in the beef cattle program. One man is now studying at Oklahoma State University and another is scheduled to leave on a fellowship within the next several months, leaving six men actively engaged in the beef cattle program. One of these men is also directing swine work at Palmira.

The new men were given a three-month training program at Tibaitatá, and then assigned to the other experiment stations. At present, technical staff is located at all five beef cattle stations.

As in previous years, a training program was conducted for a group of veterinary students from the Schools of Bogotá and Manizales during their vacation periods. These students seemed well satisfied with the training program and if more positions were available many of them would probably seek employment in some phase of the animal research programs.

BREEDING HERD MANAGEMENT

All herds have been improved by better feeding, management, and disease control measures. In some herds, at Tibaitatá, Armero, and La Libertad, it has been impossible to measure this improvement accurately because herd size is small. At other stations, such as Montería-Cereté, where herd size is adequate, one can see the results more clearly in higher calving percentage, heavier weaning weights, and in improved thriftiness and better physical condition of animals of all ages.

Tibaitatá

Work at the Tibaitatá station has been limited to selection within the small Angus herd, and to the recording of individual animal weights every 28 days. After the elimination of two sterile cows, a 100% calf crop was obtained. Average body weight at weaning for both sexes was 224 kg., an increase of 30 kg. per animal over last year. Average weight for males was 243 kg., and for females, 217 kg.

Montería-Cereté

The Romosinuano herd has been increased to approximately 450 females of breeding age, which have been randomly assigned to groups of 30 animals each. These cow groups are used as the basis of the bull proving and record of performance testing programs. Data on body weight at different ages are being collected. These data, along with type classification and the record of the progeny, are being used as the basis of selection.

In addition to the bull proving and record of performance testing programs, a study was recently started on the age at first calving, subsequent production, and ultimate body size. Owing to the slow physical maturity of the animals in this region, as in most of Colombia, females are usually bred to calve at 36 months of age. In this study, females are being bred to calve at 24 and 36 months of age. It is believed that with improved feeding and management reproductive performance can begin at an earlier age.

Armero

A pasture breeding program is being followed with the Cebú herd at the Armero station. Although herd size is small, the quality of the female stock is good. An attempt has been made to eliminate animals carrying the dwarf gene; therefore, a very rigid culling program has been followed.

A group of 50 Romosinuano heifers were transferred from Montería to Armero. Since this native breed has shown excellent promise at the Montería station, it is desirable to observe its performance under different climatic conditions. A program similar to the one at Montería will be conducted at the Armero station in an attempt to determine the adaptability of the Romosinuano to this less tropical area of Colombia.

La Libertad

Early this year the majority of the Sanmartinero cattle were transferred from Iraca to La Libertad. Since there had not been any technical supervision of the program at Iraca for several years, immediate work consisted in a culling of the animals, in an attempt to form more manageable breeding groups. Since breeding records had not been maintained at Iraca, several Sanmartinero bulls and heifers were purchased so that a breeding program could be followed without the danger of inbreeding.

Data are insufficient for definite conclusions, but it appears that this native breed may give excellent results, on a basis of weight for age, in the Llanos area.

STEER-FATTENING TRIALS

At the Palmira station, forty crossbred Cebú steers were randomly assigned to eight lots of five steers each for an evaluation of four grasses under grazing conditions. No additional supplementation was given except salt and minerals. At the end of 196 days, the steers on the pará pasture had an average daily gain of 1.11 kg.; on puntero, 0.92 kg.; on pangola, 0.80 kg.; and on guinea, 0.75 kg. This experiment will continue for another six to eight months in order to obtain data during the wet and dry seasons, and to study the effect of fertilization on forage yield as reflected by animal gain.

A pasture grazing experiment is in the process of initiation at La Libertad. Growth rate of Sanmartinero steers will be compared with that of the typical Llanos cattle.

At Cereté, a grazing trial comparing breeds of cattle has been initiated. Three breeds are being tested: Romosinuano, Costeño con Cuernos, and Cebú crossbred steers.

ARTIFICIAL INSEMINATION

Semen has been routinely collected from bulls of four breeds and, after preparation, has been shipped to various areas of Colombia for field use. Sperm physiology and morphology studies have been routinely made in an attempt to provide semen of high quality. Laboratory semen-quality tests have not been correlated with field inseminations.

Average ejaculate volume was 6.9 cc. for Holstein bulls, 5.4 cc. for Brown Swiss, 5.3 cc. for Normando, and 5.2 cc. for Red Polled. Highest average initial progressive motility, 85%, was observed in Red Polled semen, while the Normando semen had the lowest average initial progressive motility of 73.9%. Average sperm concentration per cc. of ejaculated semen, as determined with the photocolorimeter, was 1.725 billion, and average sperm concentration per cc. of prepared semen was 131,900,000. In this stud, average dilution rate was low, and concentration per cc. of prepared semen was extremely high.

SWINE

Colombians like pork, and bacon and ham of good quality are available to them. With the use of pork in the preparation of precooked meats, the swine industry is progressing in Colombia. During the past year a swine association was organized, and attention is being given to the technical direction of swine production. Since good-quality breeding stock is scarce and extremely expensive, this aspect of swine production must be aided and directed on a sound basis.

An important development during the past year has been the beginning of swine experi-

Groups of Hampshire (left) and Duroc (right) gilts at Tibaitatá.

mentation at Tibaitatá and Palmira. At both stations, gilts were used in feeding trials and will be used for future breeding studies. At Tibaitatá, the swine have been provisionally housed in the artificial insemination buildings. Thirty-six swine pastures have been seeded at Tibaitatá, and fence construction there is nearing completion. The swine buildings are not yet under construction. At Palmira, half of one of the buildings in the dairy section was adapted as a swine barn. However, land preparation and building construction have not been started on the permanent swine land area.

Two animal husbandmen employed during 1959 are now working in the swine program. The swine husbandman at Tibaitatá also works in the sheep program; the swine husbandman at Palmira is also working in the beef program at that station.

BREEDING AND RESEARCH

Tibaitatá

To begin work in the swine program, 14 Duroc Jersey and 6 Hampshire gilts, and 2 male Duroc and 2 male Hampshire pigs were purchased. These animals were divided into four groups, and were maintained on growing-fattening rations until they reached an average weight of 100 kg. Feed conversion ranged between 3.62 and 5.36. The purpose of the work was to gain experience in swine feeding and management and to raise breeding stock that will provide pigs for future experimental work.

Palmira

In a preliminary experiment at this station, 20 Duroc gilts and 20 Duroc barrows were separated into eight experimental groups. Four commercial diets are being fed. During the first 21 days of the experiment, average daily gain on diet "A" was 0.57 kg.; on diet "B", 0.62 kg.; on diet "C", 0.56 kg.; and on diet "D", 0.55 kg. As at Tibaitatá, the purpose of this work is to train personnel, obtain experience, and raise breeding stock for future experimental work.

SHEEP

The sheep industry of Colombia received more favorable publicity than any of the other animal industries during the past year. The textile industry has become quite concerned about the shortage of wool, especially of high-quality wool for clothing manufacture. With the formation of a National Sheep Campaign and with technical, governmental, and industry support, it is believed that sheep production will increase rapidly during the next several years. Perhaps the most encouraging progress during the year has been the active effort to purchase a new sheep experiment station so that effective research may be conducted.

During the past year, work with sheep was initiated at Tibaitatá. The animals were housed temporarily in the artificial insemination section. Approximately 50% of the sheep area has been prepared and seeded, and fence construction on the seeded area is nearing completion. At San Jorge only maintenance work has been done, since this station will probably cease to function as soon as the new sheep station has been purchased and put into operation.

There is one full-time sheep husbandman working at the San Jorge station, and one combined swine-sheep husbandman at Tibaitatá. During the past year, both of these men have been given additional training in sheep husbandry and management; additional facilities are needed, however, before adequate research training can be provided.

BREEDING AND RESEARCH

Tibaitatá

The sheep program at Tibaitatá was started with the transfer of 110 animals from San Jorge. These animals were all placed in an internal-parasite control study. The data resulting from this experiment are presented in the report of the animal pathology section. Upon completion of the parasite study, these animals were divided into four groups that have been used in several management, nutrition, and physiological studies. Since most of these projects are long-range in nature, definite conclusions cannot be presented at this time. Thus far, however, from 31 ewes that gave birth, there have been 7 lambs born dead, and no twinning. Average growth rate of the 24 survivors can be seen in Table 1.

San Jorge

The crossbred Romney Marsh herd has been increased to approximately 600 animals, of which 326 females are of reproductive age. It is planned to maintain approximately 300 breeding-age females of this breed, since additional breeding stock is to be imported during 1960.

Average wool production on 429 animals was 3.70 kg. per animal. During the year, 11 rams were placed with breeding groups of from 20 to 30 females each. From the two breeding and two lambing seasons per year, 218 ewes lambed, 13 giving birth to twins, an incidence of 5.96%. The reason for the low twinning percentage is unknown. Mortality in lambs was 4.74%, which was significantly lower than during past years. A 95% lamb crop was obtained during the lambing season of December and January. This was an increase of 10% over last year, and is the highest figure thus far obtained at San Jorge.

Animal Science Laboratory

Personnel of the animal science laboratory made a total of 7,500 laboratory analyses during the past year. This service laboratory has assisted all programs, especially in the fields of nutrition, physiology, and pathology.

PHYSIOLOGY

Blood studies have been made on the Angus and Holstein cattle at the Tibaitatá station. Hemoglobin, calcium, and phosphorus were determined in Holstein animals. Average blood cholesterol values in both Angus and Holstein animals 18 months or younger was found to be 146.70 mg. per cent.

Blood studies were made for diagnostic service in sheep, cattle, swine, and poultry. Hematological studies were also made on sheep used in the parasite study.

HISTOPATHOLOGY

Histological sections from 310 animals were prepared and studied. Normal and abnormal tissues are being collected from various species for diagnostic and training purposes.

DIAGNOSTIC SERVICE

Routine fecal examinations for parasites were made with samples from cattle, sheep, and swine; the majority of the work in the sheep parasite study was carried out by the laboratory personnel. In addition, some bacteriological and blood studies were made for diagnostic purposes. The bacteriology section is to function in the veterinary clinic and for this reason little emphasis has been placed thus far on the development of the bacteriology work. Diagnostic service has also been done with brucellosis testing.

NUTRITION

A total of 977 feed samples was analyzed during the past year. These consisted of raw

TABLE 1.

Average growth of 24 lambs born at Tibaitatá.

Age	Body weight (kg.)	Height withers (cm.)	Height back (cm.)	Depth chest (cm.)	Width chest (cm.)	Circ. chest (cm.)	Length body (cm.)
Birth	4.2	35.2	35.6	15.5	10.0	38.6	41.7
Weaning (90 days)	17.6	49.7	50.3	23.9	15.7	66.2	67.6

materials, mixed diets, and silages. An attempt is being made to set up a table of standard values for local feedstuffs as an aid in diet formulation. As in other years, the milk analyses were made in the animal science laboratory.

POULTRY

Contrary to the situation which exists in some other countries, poultry is a luxury item in Colombia. Eggs, too, are expensive to produce and expensive to the consumer. Although poultry production in Colombia has changed over the past several years from a backyard industry to one of a commercial nature, it will be some time before the cost of production is low enough to permit the daily consumption of both meat and eggs by all persons in the country.

Research in poultry husbandry, including nutrition, breeding, management, and hatching studies, is presently being conducted at the Tibaitatá and Palmira experiment stations. The Medellín station is to be placed in operation by May, 1960.

A major achievement of the poultry program during 1959 was the putting into operation of the Tibaitatá section, where the entire unit is now almost complete. At the Palmira station, little development of facilities has been accomplished during the past year, other than the completion of the building for offices, incubation, and egg storage.

Two new poultry husbandmen have been added to the staff during the past year, so that there is now a nucleus staff at each of the three experimental farms. These men received preliminary training at Tibaitatá, and were then permanently assigned to their respective stations.

RESEARCH

Tibaitatá

Six poultry experiments, primarily broiler and layer nutritional studies, were started

New Hampshire layers at Tibaitatá.

during the past year, and some of these are still in progress.

To begin operations in the poultry program at Tibaitatá, 1,200 New Hampshire chicks were allotted to seven experimental diets. The experiment was designed to compare five commercial broiler rations with two diets mixed at the experiment station. Birds on diet "B" had an average body weight of 478 gm. at five weeks of age, while those on diet "A" had an average body weight of 307 gm. At 12 weeks of age, the birds on diet "B" averaged 1,645 gm. Feed conversion ranged between 2.59 and 3.14 from 0–8 weeks of age, and between 3.81 and 4.83 from 0–12 weeks of age. The profit per bird over feed cost, up to 12 weeks of age, ranged between 7.53 and 5.26 pesos.

The best females from the experiment were saved, continued on commercial diets, and maintained on the floor. The average age at first egg was 18 weeks of age, the percentage of production at the end of the second month was 55% and at the end of the third month, 52.9%. A 3.2% mortality rate was noted up to the end of the third month of production. At the end of the third month of production, some layers were moved to individual cages and others into colony cage groups. Some of the hens were maintained on commercial diets and others were placed on mixed rations, in an attempt to determine the replacement value of milo for corn and of sesame for soy, and to judge the value of added materials in bringing about a darker pigmentation in egg yolk color.

A second broiler nutrition study was conducted in an attempt to determine the replacement value of sesame for soy and the replacement value of milo for corn in broiler rations. At the end of the fourth week, the controls averaged 270 gm., while results from experimental diets were inconsistent. It was found that the soybean meal prepared in Colombia for poultry is not properly processed.

Because of the results obtained in the previous experiment, a trial was started to determine the effect of heating soybean meal (autoclaving). In this same experiment, products were tested in an attempt to find a supplement for animal protein in broiler diets, since it is extremely difficult to obtain a standardized animal protein. At the end of four weeks, the birds on the heated soy were, on an average, 39 gm. heavier than those on the control diet.

Palmira

The first experiment at Palmira was a study on broiler nutrition in which four commercial diets were tested. At five weeks of age, birds on diet "B" had an average body weight of 461 gm. while those on diet "C" had an average body weight of only 242 gm. A comparable difference was observed in the 12-week weights; birds on diet "B" weighed 1,485 gm., while those on diet "C" weighed 879 gm. Feed conversion from 0–5 weeks varied from 2.37 to 4.55, and from 6–12 weeks, from 3.74 to 5.77.

The females from this experiment were saved, and fed commercial pullet-growing rations. At the beginning of production, they were switched to layer diets and maintained on the floor. Production has been between 60% and 65% on a hen-day basis. At the end of six months of production, a selection was made of the hens that had laid over 130 eggs and whose average egg weight, in the last five eggs, was over 54 gm. These were placed in breeder pens, and are being used to provide eggs for hatching replacement stock. Hatching percentage has been approximately 85%. The chicks that are being used at Tibaitatá for the nutritional trials were hatched at Palmira.

In a second broiler experiment, 1,200 New Hampshire chicks were allotted to six experimental diets: four commercial and two mixed diets. Results were comparable to those of the similar experiment conducted at Tibaitatá. The pullets from this experiment were grown on the floor and when they entered into production were placed in a nutritional trial to evaluate levels of antibiotics in layer diets.

In a recently initiated broiler experiment, the replacement value of milo for corn and of sesame for soy is being tested in New Hampshire and White Rock chicks. Females will be used in future pullet and layer studies.

Angus cows in one of the recently seeded pastures.

Dairy Science

Dairy husbandry investigations have been conducted, as in previous years, at five stations: Tibaitatá, Palmira, Obonuco, Toluviejo, and El Nus. Since the dairy program is relatively new, considerable time is still spent in developing the organization, preparing land, and planning and constructing facilities. While there is still much work of this kind to be done, facilities at four of the five farms are such that more emphasis can now be given to the research program. Facilities at Cereté, which will replace Toluviejo, are not yet developed and progress there will proceed as conditions permit.

MANAGEMENT OF HOLSTEIN HERDS

The development of adequate herds, not only from the viewpoint of animal numbers but also in terms of satisfactory management procedures, good animal quality, and accurate record-keeping, is necessary for the success of the research program. Methods of keeping herd data are being improved and management procedures standardized. Herds are being culled as rapidly as possible, but because of limited numbers of animals, the number removed is being held to a minimum. Herds will be increased in size by purchasing animals but reproductive increase will also be necessary to obtain the number of animals needed for research.

MILK PRODUCTION

In general, productive performance improved during the past year because of culling, better management, and improved feeding, particularly better forage.

The 32 cows at Tibaitatá which finished lactations during 1959 produced an average of 5,843 kg. of milk per lactation, equivalent to better than 12,800 pounds. This is certainly a satisfactory production level and its achievement shows that a high level of production in some areas of Colombia is a reasonable possibility. These cows were fed grain at a level of approximately 1 pound of grain to 3 of milk. This is probably a higher level of grain feeding than is profitable under present conditions in Colombia. In this case, however, it is desirable to determine first what is possible and second what is practical. This is important for several reasons: (1) to understand better the genetic potential of the animals with which we are working; (2) to measure the general quality of herd management; (3) to establish the general level of feed quality, especially roughage; (4) to demonstrate to dairymen the possibilities (it always is a stimulus to local people that a potential equal to that of well-developed countries exists, even though it may not be practical at the present time); and (5) to establish a broader range of production levels so that the economical level can be approached from below and above rather than solely from below.

The over-all herd productive level of the three Holstein herds during 1959 can be evaluated from the data presented in Table 1.

The cows at Palmira and Obonuco produced less milk than those at Tibaitatá. Although the cows at Palmira probably have as much genetic potential as those at Tibaitatá, production has been held down by the warmer weather, lower-quality roughage, and the general herd management. The cows at Obonuco are of lower genetic potential; on a percentage basis, however, they have improved more than the other herds, owing to improved roughage quality and good management.

HERD EFFICIENCY

Several measures of general efficiency are being applied to the herds. While these data will be more valuable when compiled over a period of several years, they are useful at present for evaluation of management and herd health, and as guides in bringing existing problems into focus. The following data are from the year ending October 31, 1959.

Intervals between calvings averaged 377, 434, and 440 days at Obonuco, Palmira, and Tibaitatá, respectively. The intervals at Palmira and Tibaitatá are somewhat long, but not exceptionally so.

Over a relatively short period, either services per conception or the efficiency of first services is probably a better index of fertility than calving intervals. At Pasto, Tibaitatá, and Palmira, 2.3, 2.4, and 5.0 services were required per conception, excluding heifers that had not calved, an indication of seriously low fertility at Palmira. The order of efficiency for first services was Obonuco, 59%, Tibaitatá, 44%, and Palmira, 22%, with Palmira again showing a serious breeding problem. Similar data for heifers (not having calved) are Pasto, 83%, Palmira, 54%, and Tibaitatá, 44%. While the number of animals is too small for definite conclusions to be formed, the data indicate that the main problem at Palmira is in the adult cows and not in the heifers.

TABLE 1.

Milk production of Holstein herds during 1959.

Station	Kg. milk per cow day	Kg. milk per productive cow day	Av. no. cows per day in herd
Tibaitatá	13.3	17.4	46
Palmira	9.3	13.0	41
Obonuco	7.9	10.1	31

These data, along with other more detailed records, serve to evaluate the experimental herds, help in training personnel in herd management, and can be used as guides in commercial herd managements.

MANAGEMENT OF CRIOLLO HERDS

The herd of Blanco Orejinegro (BON) cattle is located at San José del Nus in Antioquia; the Costeño con Cuernos (CCC) cattle are located at Toluviejo in Bolivar. It is planned to move the CCC cattle to Cereté and the progress of studies with this breed, as well as other phases of the dairy program in the hot north coast area, will be dependent upon development of facilities at Turipaná, the new Cereté station. However, a small amount of milk production data was collected, and other observations characterizing the breed and its management were made.

At El Nus, the organization of the farm and the work has been improved, and although there are still some facilities to be developed, the work can go forward. Production data and other measures of efficiency will be considered as research data of the selection programs of these breeds.

One serious management problem has arisen at El Nus. Calves of the BON breed had never been raised by hand, except for a few individual animals. In order to evaluate more accurately the BON cattle for milk production, a calf-raising program was initiated

Dry cows and heifers at the water tank at Tibaitatá. The new dairy buildings can be seen in the background.

wherein calves were taken from dams and raised in individual stalls. At first, the system was unsuccessful because of infections in the barn. This problem was corrected and the barn-raised calves now grow better than those nursing dams in the field. It was found, however, that barn-raised calves are unadapted to field conditions and become victims of parasitic infections. The next problem is to find a means of adapting barn-raised calves to field conditions.

MILK PRODUCTION

Two years' milk production data are now available on the pure BON, and three-fourth BON—one-fourth Jersey cattle in the herd at El Nus. Production is very low but, in addition to the breed, one must take into account the hot weather, fibrous roughage, and low grain feeding. Of the 156 pure BON which have finished records during the calendar years 1958 and 1959, only 9% produced more than 1,500 pounds of milk, while 24% of 54 quarter-blood Jersey exceeded this production.

Milking the CCC cows without the calf at side was initiated during 1959. From preliminary data, the milk-producing ability of this breed appears to be similar to that of the BON.

The CCC and BON breeds are hardy and are well adapted to the areas in which they are found. Milk production is low, however, and lactations are short. Another characteristic of these breeds is that they tend to hold up milk if they do not have calves at their sides during milking. The prospect for selecting these breeds as profitable dairy animals is poor; however, the possible value of introducing some genes from higher milk-producing breeds is indicated by the greater percentage of higher-producing cows among the one-fourth Jersey crosses. In general, no lack of adaptability has been noted in these quarter-blood animals as compared with pure BON.

FROZEN SEMEN

Frozen semen, preserved in liquid nitrogen, has recently been imported for use in the

Holstein herds. This semen from proven bulls should be a major aid in the improvement of dairy herds and its use demonstrates another available technique which can be considered for adaptation on a larger scale in Colombia.

RESEARCH ON CALVING

Studies have been carried out in the length of gestation of the breeds with which the program is working, and data on the subject are now available. A summary of this information is presented in Table 2.

The size of calf at birth is a characteristic of animal populations, and comparisons have been made in regard to this factor. The available data, presented in Table 3, indicate a difference between Holland Holstein and U. S. Holstein calves, and give values for the two criollo breeds.

The general opinion that the criollo breeds are slow in development can be accepted as fact within the environment in which they are raised. It is not known, however, to what extent development is influenced by environment.

The average age at first calving for 349 CCC heifers was 1,212 ± 10 days. For the 76 BON heifers which calved in 1958, the average age was 1,174 days. The average calving age for 55 heifers which calved in 1959, when an effort was made for earlier calving, was 1,087 days. Thus, calving age can be influenced by management and can probably be influenced even more by nutrition.

It is generally accepted that a desirable interval between calvings of the dairy breeds in the United States would be 12 months. Seldom is this interval realized. The lower-producing criollo breeds, however, should be able to approach this interval. At El Nus, the average interval between the last two lactations of 241 cows was 381 days. However, a more detailed study at Toluviejo of the CCC cattle shows longer but quite constant intervals (Table 4).

MANAGEMENT AND NUTRITION OF CALVES

The loss of calves during the first year is high in Colombia even though the calves receive relatively large amounts of milk. Studies now under way are directed at improving management and reducing the amount of milk.

Calves in dairy herds in Colombia normally receive 600 to 1,000 kg. of milk. Preliminary studies conducted at Palmira and Tibaitatá with Holstein calves clearly demonstrated that with good management calves could be raised with 212 kg. of milk, and weaned at eight weeks. In areas where there is a good market for milk, this system reduces the cost of raising calves by 50% during the first four months.

A second study at Tibaitatá was directed to improving the concentrate (starter) ration for raising calves with limited milk. Further reduction of milk is now being studied. Three calf groups are receiving 212, 170, and 138 kg.

TABLE 2.

Average length of gestation of four cattle breeds.

Breed of sire	Daughters		Sons	
	Number	Av. days gestation	Number	Av. days gestation
Holstein (American)	29	279.2	19	280.4
Holstein (Holland)	17	278.2	15	276.6
BON	9	283.4	11	285.0
¾ BON–¼ Jersey	11	282.6	7	282.8

TABLE 3.

Average weight at birth of calves of five breeds.

	Daughters		Sons	
Breed of sire	Number	Av. wt. (kg.) at birth	Number	Av. wt. (kg.) at birth
Holstein (American)	29	37.0	19	39.4
Holstein (Holland)	14	33.1	15	37.0
BON	353	25.4	806	27.1
¾ BON-¼ Jersey	111	25.0	121	26.2
CCC	123	24.0	172	26.0

of milk, and it appears that even the lowest milk group will be satisfactory. Therefore, the cost of raising calves can be even more reduced.

At El Nus, the BON calves had never been raised by hand. A system was initiated by which calves were raised in individual stalls and fed milk, grain, and roughage. At 120 days of age, barn-raised calves weighed an average of 81 kg., while calves raised in the field with dams weighed an average of 72 kg. This speaks well for the barn-raising system, but barn-raised calves, as mentioned earlier, are not as well adapted to field conditions and suffer severe setbacks. The present problem is one of transition from the barn to the pasture field.

Since bedding is a problem in tropical areas, a project was initiated to compare false slatted floors without bedding and cement floors with bedding.

Frequency of rumination has been observed during 24-hour periods in order to understand something of the development of the rumen of Holstein calves raised under the experimental systems. The time spent ruminating indicated that rumen development was rapid, and reached a maximum at from five to eight weeks of age.

Observations were made at Tibaitatá of phosphorus, calcium, and hemoglobin in the blood of experimental calves. Phosphorus and calcium were considered normal. Hemoglobin is probably normal for this elevation of 8,600 feet; 134 analyses in calves from birth to 120 days of age averaged slightly more than 14 gm. per 100 ml.

ROUGHAGE

Even in relatively mature forages, high moisture has been a problem in making silage. Moisture content of some common forages, such as oats and alfalfa, at different stages of maturity has been determined and the data show the desirability of wilting the crops before ensiling. With use of adequate amounts of preservative, such as 10% ground corn, good-quality silage can be made but run-off or

TABLE 4.

Average length of lactation intervals of CCC cattle at Toluviejo.

No. of animals	Lactation interval	Length, in days, of lactation interval
350	1–2	507 ± 8
253	2–3	452 ± 8
211	3–4	437 ± 9
163	4–5	438 ± 12
122	5–6	459 ± 12
88	6–7	450 ± 17
61	7–8	450 ± 15
36	8–9	449 ± 19

seepage is excessive. Studies have been initiated recently to evaluate silage preservatives.

Some data were collected at Palmira in a comparison of guineagrass, pará, and pangola as pastures for milking dairy cows. Dry weather hindered the study and no differences were observed among these three grasses.

New plots were seeded at Tibaitatá to evaluate kikuyu and a mixture of English ryegrass, orchardgrass, white clover, and red clover as grazed crops in comparison with alfalfa fed as green chopped forage.

Digestion trials to study roughage values will be conducted as soon as facilities permit.

All calf trials have been carried out with green or wilted forage instead of hay as roughage. The value of hay as compared with green roughage for calves will be studied as soon as possible.

A project was initiated to determine approximate analyses of common feeds from different areas of the country. This information is needed to guide the activities of the research program.

Animal science laboratory, Tibaitatá.

Animal Pathology

VETERINARY RESEARCH LABORATORY

There is a great need for more research on animal diseases in Colombia. Lack of information on the incidence and severity of various animal diseases and on control methods for them is handicapping the development of the country's livestock industry. The present research, though frequently of high quality, is limited by shortages of funds, equipment, and trained personnel. It is hoped that the construction of three veterinary research laboratories at Bogotá, Palmira, and Cereté and the coordination of their activities with graduate training programs will alleviate these adverse conditions.

A contract between the Ministry of Agriculture and the National University, the first between these two entities, was signed on May 12, 1959, and stipulated the conditions for the first *Laboratorios de Investigaciones Patológicas Veterinarias* (LIPV), to be built on the campus of the National University in Bogotá. The university will provide a 6.3 acre site abutting the Veterinary Faculty, and the Ministry will supply the construction funds.

Initially the LIPV in Bogotá will function as a research and diagnostic center, rendering the latter service to obtain vital and presently unknown facts on the incidence and epidemiology of animal diseases in Colombia. For the efficient performance of these functions it is of the utmost importance that continued cooperation be maintained between the LIPV and the veterinary schools. The two units must supplement each other, the faculties supplying the much-needed personnel and the LIPV providing specialized training and equipment for research and for joint projects. To further advance the faculties, additional funds for equipment, books, and particularly for fellowships must be made available.

The first tentative plans for the laboratory have been improved considerably to utilize the limited land area more effectively, to promote efficiency, and to reduce sources of bacterial or viral contamination. The alterations in the plans have been reviewed by Mr. Norval Curry and by engineers and veterinary staff members of the U.S. Department of Agriculture and of several universities. Detailed plans are now being prepared by commercial architects in Bogotá and it is hoped that construction on the LIPV can commence promptly when the plans are complete. Construction of the laboratories at Palmira and

Cereté will not begin until the Bogotá unit is completed.

The laboratory at Bogotá will have 11,245 square feet of floor space, including 2,368 square feet of negative-pressure animal isolation quarters. These isolation quarters will reduce the occurrence of extraneous diseases and the possibility of infecting animals outside the laboratory area. As a further precaution, sewage and wastes will be either incinerated or steam treated.

Quarters for large animals, swine, and poultry, though not isolated, will provide physical separation to reduce accidental infection of experimental animals. A laboratory animal colony, store and equipment rooms, and workshop will be housed in the existing sub-laboratory when it is remodelled. The stables and exercise lots will be surrounded by a security fence, so that although interested personnel can readily gain access, they must first enter the laboratory. In this way, traffic will be controlled and sources of contamination will be reduced.

SERVICE CLINICS

Veterinary clinics are being developed at all ten experiment stations which have livestock. Some of the clinics are provisional but they are being improved so that each will consist, in the future, of a laboratory, an autopsy-surgery area, and an insolation-treatment area.

All clinics, with the exception of the one at La Libertad in the Llanos, now have the basic equipment necessary for the maintenance of animal health and for the prevention of disease. In the future all the clinic laboratories will be provided with equipment for simple bacterial cultivation and sensitivity testing, in addition to the existing clinical equipment. Tissue and autopsy material for micropathologic examination are being collected at all stations.

Only recently have veterinarians been available to staff all clinics. Five graduates of the 1959 veterinary classes were awarded positions with DIA in August, attended a three-month training and orientation program at Tibaitatá, and were then located at the various clinics. Eight veterinarians are now practicing solely in the veterinary section, while two are acting jointly in animal pathology and husbandry sections.

At this time, the limited personnel in the veterinary section are occupied with the health of over 4,000 head of experimental animals, at the expense of laboratory and investigational work.

More than 1,300 diagnoses and treatments, 1,365 laboratory examinations, and a large unrecorded number of management procedures were performed by the clinic veterinarians during the past year. It should be noted that some clinics were staffed and accurate records kept for only a short time during 1959. Many of the diagnoses are clinical and though in most instances there is no question of their validity, all were not substantiated with laboratory examinations.

A résumé of the conditions encountered is presented in Table 1. Blood parasitism of cattle in the tropic and semitropic areas was a frequent and severe problem. It will be noted that vesicular exanthema coital was encountered. This viral infection was diagnosed with the cooperation of *Instituto Zooprophylactico* and represents the first such diagnosis in Colombia. Evidently this infection was introduced into the artificial insemination center at Tibaitatá by imported bulls. Because of the lack of quarantine facilities, these bulls were shipped directly to the center and infected the entire stud and other livestock on the farm. This incident illustrates the need for quarantine stations in Colombia and for the separation of the insemination center from the experimental livestock of Tibaitatá. It is fortunate that a more grave condition was not introduced.

SPECIAL STUDIES

The shortages of staff and equipment and the demands of the routine services have pre-

TABLE 1.

Partial list of diagnoses performed by veterinary clinic personnel, January, 1959 - December, 1959.

MAMMALS	
Abortion (various)	9
Abscesses	8
Actinomycosis	5
Aftosa (vaccination breaks)	296
Allergies	4
Altitude disease (brisket disease)	4
Anaplasmosis	35
Anemia	1
Anthrax	2
Arthritis	4
Atony (rumen)	2
Babesiosis	4
Bloat	39
Bronchitis	1
Brucellosis	8
Cachexia	3
Clostridium chauvoei	1
Clostridium hemoliticum	1
Clostridium perfringes	2
Coccidiosis	14
Colic	6
Conjunctivitis	1
Cystic ovaries	11
Dermatitis (non-specific)	6
Dictyocaulus	79
Diphtheria	8
Distemper (canine)	1
Dwarfism (Aberdeen Angus)	3
Dystocia (ovine)	2
Enteritis (other than calf scours)	183
Essential hematuria	1
Footrot	13
Gangrene (unclassified)	2
Goitre	8
Gonitis	1
Hematomas	2
Hemorrhagic septicemia	11
Hog cholera	7
Icterohemoglobinuria	2
Injuries and accidents	29
Injuries (teat)	11
Intoxications (various)	20
Lameness	3
Listeria monocytogenes	2
Mange	4
Mastitis (unclassified)	52
Metritis	17
Milk fever	5
Mummification	1
Myelitis	1
Myiasis	21
Necrosis (tail)	1
Nephritis	1
Omphalitis	6
Otitis externa	2
Peritonitis	1
Piroplasmosis	9
Pneumonia	16
Retained placenta	19
Rhinitis (porcine)	1
Rickets	1
Rumen impaction	1
Salmonellosis (type unclassified)	1
Scours, infectious	98
Scours, simple	179
Teat spider	1
Traumatic reticulitis	1
Trypanosomiasis (type unclassified)	1
Tuberculosis	7
Tumors	2
Ulcers	3
Undiagnosed	14
Uterine prolapse	1
Vesicular exanthema coital	11
Vitamin A deficiency	1
Vitamin E deficiency	1
Warts	9
TOTAL	1,344
ROUTINE LABORATORY EXAMINATIONS	
(Blood, feces, etc., excluding experimental, investigations.)	
TOTAL	1,365
POULTRY	
Asphyxia	3
Cannibalism	2
Cholera	21
Coccidiosis (intestinal)	48
Diarrhea	4
Fowlpox	21
Injuries	3
Lymphomatosis	9
Perosis	19
Prolapsed oviduct	10
Pullorum reactors	4
Undiagnosed	51
Vitamin B_2 deficiency	13
Vitamin E deficiency (Encephalomalacia)	20
TOTAL	228
OVER-ALL TOTAL	2,937

vented the initiation of many investigations. This situation is likely to continue until the clinics are further developed and staffed and the research laboratories are functioning. It has been possible, however, to initiate several studies during the past year, and it is hoped that additional studies can be started during the current year.

DERMATOBIA HOMINIS

Infestation with the larval form of *Dermatobia hominis*, locally termed "Nuche," is a limiting factor in the production of livestock in the semitropical areas of the entire Andean range. In cooperation with the entomology section, an investigation of the life cycle and control of *D. hominis* has been initiated. Although this study is an extensive and continuing project, initial results can be noted.

A trial was established at San José del Nus to study the existing methods of control, such as manual expression, toxaphene baths, and lindane-tar applications, as compared with systemic phosphatic insecticides, injected and applied as sprays. A total of 140 Blanco Orejinegro steers were used in the experiment. The results, in brief, indicate that systemic phosphates offer more effective and longer control than previously possible.

Retreatments with the phosphates were necessary at six-week intervals, while manual expression, lindane applications, or toxaphene baths were necessary on a weekly or biweekly basis. Toxaphene effectively controlled ticks, but was ineffective in controlling "Nuche." It is hoped that other control methods, including aerial spraying, can be studied.

Studies on the life cycle of *D. hominis* have not been completed. It has been found, however, that the important egg vectors are *Callitroga hominivorax* and *C. macellaria*, the primary and secondary screw-worm flies which plague the cattle industry in the southern United States.

SHEEP PARASITISM

A lengthy study of the incidence, identification, and classification of enteroparasites of sheep in the savannah of Bogotá has been initiated. Although the results have not yet been fully compiled, the following species were identified in the intestinal contents of two sheep: *Haemonchus contortus*, *Strongyloides papillosos*, *Ostertagia circumcinta*, *Cooperia curticei*, *Trichostrongylus colubriformis*, *Nematodirus filicollis*, *Oesophagostomum venulosum*, *Chabertia ovina*, *Trichuris ovis*, *Dictyocaulus filaria*, *Monezia expansa*, and *Cisticercus tenuicollus*.

The presence of continued moisture and intensive rearing conditions in the savannah and surrounding mountains make parasitism a limiting factor in the successful rearing of sheep in the area. The efficacy of several locally available nematocides was studied and a demonstration of control measures made. The necessity for pasture rotation, periodic fecal examination, and treatment was demonstrated.

OTHER STUDIES

Studies are being made on brisket or edema disease of cattle, and on the control of *Dictyocaulus* spp. (lungworm) in ruminants, enteroparasites of calves, and coccidiosis of poultry.

Biometry

The biometry section aids all the major programs of DIA in the planning, analysis, and interpretation of experiments. During 1959, emphasis shifted from routine computing of experimental results to the study of factors affecting the precision of experiments. The development of a well-trained staff continues to be stressed.

COMPUTATIONAL SERVICES

Data from all experiments conducted at Tibaitatá are now processed by the biometry section. In 1959, new desk calculators were obtained and operators were trained to use them. Computational work is now up to date at Tibaitatá; most analyses are completed less than a week after receipt of the experimental data. During the period covered by this report 722 experiments were processed.

Computational services are being extended to other stations. About 60% of the experimental work in DIA is done outside Tibaitatá, where the work of the statistics program has been concentrated until now.

Experimental use of a high-speed electronic computer is planned for 1960. By such means it may be possible to increase the data-processing capacity of the statistics section without a corresponding increase in the number of office personnel.

FACTORS AFFECTING PRECISION OF EXPERIMENTS

When the cooperative work of the Colombian Ministry of Agriculture and The Rockefeller Foundation was initiated in 1950, information on soil variability was lacking. Practices which had proved useful in Mexico and the United States were consequently adopted, with remarkable success. Review of these procedures, however, has long been overdue. In 1960 the biometry program initiated studies of experimental techniques in corn at Tibaitatá. Number of replications and plot size required for a specified degree of precision can be determined from the data of yield trials and other experiments already performed. Thus the analyses of variance already calculated by the biometry section are used to improve precision in future experiments.

Preliminary results indicate surprising differences in soil variability at Tibaitatá. Land at the northern end of the station is most suitable for precise work; relatively large plots and few replications will be recommended. The southern part of the station is more variable; more replications and smaller plots are required, and a high degree of precision cannot be expected.

TRAINING

Review of experiments in the field is important in training the two Colombian agronomists assigned to the biometry program. The cooperation of the pasture and forage crops program has been helpful in this work. The plants used in nearly all forage crops experiments are perennial. By comparing forage plots with the data from earlier clippings, the students comprehend visually the theoretical principles taught in the statistics laboratory. Fundamental to the training program in biometry is the concept that theory and practice are mutually dependent.

Training in experimental techniques and principles extends to other sections. Short courses in special aspects of statistics, such as one in statistical genetics for certain personnel of the corn section, have been presented. Consultation presents opportunities for the discussion of statistical principles, and such discussion furthers an important function of the statistician: to guide the youthful enthusiasm of the inexperienced agronomist into practicable channels. This frequently involves stressing the advantages of a program of several small, simple, clear-cut experiments, each executed with careful attention to detail. The aims of the statistician in consulting work are thus twofold: to aid in the discovery of facts and to develop the agronomist's ability to perform successful experiments.

Farm Administration

The work of the farm administration program during the past year has again been devoted primarily to land development and construction. Progress at Tibaitatá was severely retarded by the loan of trained personnel and heavy equipment from this station to other farms. This lending was necessary, however, because Tibaitatá was at least sufficiently finished to function, while many of the other farms were not.

Because of budget limitations, it has been impossible so far this year to increase the number of men in the construction crew at Tibaitatá. The program continues to lose trained men in all categories because of an inability to meet competitive wage scales.

Construction and Field Improvement

TIBAITATÁ

The Colombian administrator of Tibaitatá resigned during the past year, and a new man is now in this position.

Field work necessary for the crops programs has been accomplished, and over 100 acres of new pastures have been planted. Over 1,000 tons of silage have been made.

A canal of 3,700 cubic yards was dug to complete the drainage irrigation system for the dairy unit.

A high-tension power distribution system, 3,240 feet in length, has been installed and is now in operation with transformers totaling 322 kva. This new line is of sufficient capacity to handle future expansion.

To serve the animal industry section, a water supply system consisting of 1,400 feet of 3-inch pipe has been installed and checked under pressure. The contracted water plant should be in operation soon. The animal clinic and three buildings in the poultry section have been completed and put into operation. One more silo has been completed and is in use. A shortage of bricks has held up construction of the three silos, which are still to be finished.

After a thorough study of the possible methods of repairing the roof on the main building at Tibaitatá, a contract has finally been signed and work initiated.

An addition to the supply warehouse, totaling 3,000 square feet, is under construction.

A cooling unit has been installed in a greenhouse of the plant pathology section. Soil bins, benches, and a room with controlled light have been built in the head house.

An insectary has been completed.

SURBATÁ

All of Surbatá's 197 acres have been plowed. In the last semester of 1959, about 60 acres were irrigated, leveled, and planted to potatoes. This land is now planted to experimental wheat, barley, corn, and beans.

A high-tension power line, approximately three-quarters of a mile long, has been installed and at present is operating with a 25-kva transformer of sufficient capacity to allow for future expansion. The high-tension line has a capacity of 400 kva.

The old hacienda on the farm has been completely remodeled and is being used for offices and living quarters.

Grain storage, potato storage, and farm shop buildings, with combined floor space of approximately 8,000 square feet, are nearing completion.

Approximately 2,000 cubic yards of soil have been moved by dragline to initiate the canal system for both drainage and irrigation. One mile of fencing has been constructed.

NATAIMA

A grain storage building of 2,600 square feet, with a drying platform of 7,098 square feet, has been completed and is in use. A farm shop and machinery storage building, 2,600 square feet in size, is in operation. A four-bedroom house and a supply building have been started. Land work has progressed well and some roads have been made.

TURIPANÁ

Approximately 3 miles of roads have been surveyed and bulldozed clear, but have not yet been surfaced because of lack of equipment. Approximately 100 acres have been cleared, plowed, harrowed, and partially leveled for planting during the first semester of 1960.

An old house on the farm has been reconditioned and will be used as a field office and living quarters until new buildings can be constructed. The provisional farm shop has rebuilt most of the old machinery, and some new equipment has been obtained.

A study has been made of the Montería-Cereté area to find a new location for the airport, which at present is located on the new farm and precludes any building construction. A new site, favorable to all concerned, has been found and is being surveyed. With this problem resolved, construction will begin as soon as the weather permits. Building plans have been completed for some units of this new farm. Storage and farm shop facilities will be constructed first, since these are needed in the development work; dormitory and kitchen facilities will be built later. Procuring labor is a problem, because of the difficult living conditions in the area.

LA LIBERTAD

At this new farm near Villavicencio, a machinery shed, a stable, and various modifications to existing buildings are nearing completion. A new power plant and a new electric pump for the water system have been installed. Sufficient equipment, tractors, cutters, and other machinery, have been put into operation to maintain all pastures.

ARMERO

A bulldozer and operator on loan from Tibaitatá have been at work on the land at Armero, and approximately 180 acres have been cleared of stumps.

Two buildings, with a total of 3,100 square feet of floor space, are nearing completion, as are numerous corrals and a road system.

OBONUCO

A grain storage building, with 2,600 square feet of floor space, has been completed and plans have been made to construct a general storage building and a new farm shop. A water system about 1 mile long is being built to bring drinking water to the building area. Land clearing and road building have progressed well. An insectary has been completed.

NEW FARMS

By government decree it has become necessary for DIA to establish two new farms, one in the lower Magdalena area and one in the Atlantic coastal area. Three separate studies have been made of these two areas and detailed reports have been presented to the proper authorities.

SEED DISTRIBUTION

Seed has been sent from the Colombian Agricultural Program to the following individuals and institutions:

Name	*Institution*	*Location*
L. A. Wiley	National Institute of Agricultural Botany	Cambridge, England
———	U. S. Department of Agriculture	Washington, D. C.
W. T. Fike	North Carolina State College	Raleigh, North Carolina
Edgar Anderson	Missouri Botanical Garden	St. Louis, Missouri
Alphonse C. Chable	Division of Agriculture	Quito, Ecuador
F. A. Aquilazan	University of the Philippines	Laguna, Philippines
Vladimir Trifunevich	Institut za Ratarstvo	Yugoslavia
E. J. Wellhausen	The Rockefeller Foundation	Mexico, D. F., Mexico
M. Harrison	Agricultural Laboratories	Nairobi, Kenya
E. W. Sprague	The Rockefeller Foundation	New Delhi, India
Colin Campbell	Garnett & Co.	Georgetown, British Guiana
Hugh F. Rouk	Ethiopian College of Agriculture and Mechanical Arts	Jimma, Ethiopia
A. C. Evans	Department of Agriculture	Dar-es-Salaam, Tanganyika
E. R. H. Martin	Ministry of Agriculture	Kingston, Jamaica
V. Fortuno	Agricultural Experiment Station	Río Piedras, Puerto Rico
J. Dickson	Ansor Corporation	San Francisco, California
Heliodoro Miranda	Universidad Central	Quito, Ecuador
Ignacio Narváez	The Rockefeller Foundation	Mexico, D. F., Mexico
H. C. Thorpe	Ministry of Agriculture	Njoro, Kenya
J. A. Rupert	The Rockefeller Foundation	Santiago, Chile
M. Ruszkowski	I. U. N. G.	Pulawy, Poland
H. de Souza López	Instituto Oswaldo Crúz	Rio de Janeiro, Brazil
W. Loegering	Plant Industry Station	Beltsville, Maryland
J. Schuler	U. S. Operations Mission	Lima, Peru
Hernan Orellana	Comisión Nacional del Trigo	Quito, Ecuador
José M. Franco	Embajada de Colombia	San Juan, Puerto Rico
George P. Freytag	Escuela Agricola Panamericana	Tegucigalpa, Honduras
Oscar D. Ramírez	Departamento de Genética de Plantas	Río Piedras, Puerto Rico
———	Narfarm, Inc.	Valencia, Venezuela
———	Hacienda Monte Sacro	Valencia, Venezuela
———	Cervecería Centroamericana	Guatemala
Eugene J. Gerber	———	Maryland
Silvio Echeverri	Oregon State College	Cornwallis, Oregon

Chilean Agricultural Program

Personnel

CHILEAN AGRICULTURAL PROGRAM

MINISTRY OF AGRICULTURE

His Excellency, **Sr. Jorge Saelzer Balde,** Minister of Agriculture

Ciro Iturriaga Garces, Subsecretary of Agriculture

Virigilio Mannarelli Montgomery, ING. AGR., Director of Agriculture and Fisheries

Dionisio Pavez Saa, ING. AGR., Coordinator of Agricultural Research

Claudio Vergara Castillo, ING. AGR., Head, Department of Agricultural Research

René Cortázar Sagarminaga, M.S., Assistant Head, Department of Agricultural Research

Mario Vallejo Varela, ING. AGR., Director, Central Experiment Station, Santiago

Alejandro Violic Martinovic, ING. AGR., Director, South-Central Experiment Station, Chillán

Alfredo Mathieu Kohler, ING. AGR., Director, Southern Experiment Station, Temuco

OFFICE OF SPECIAL STUDIES

Joseph A. Rupert, PH.D., Director, The Rockefeller Foundation
Manuel Sánchez Nelson, ING. AGR., Administrative Assistant

CEREAL IMPROVEMENT

Joseph A. Rupert, PH.D., The Rockefeller Foundation (until August, 1959)
Robert W. Romig, PH.D., Associate Agronomist, The Rockefeller Foundation
René Cortázar Sagarminaga, M.S., in charge, Cereal Improvement (on leave)
Ignacio Ramírez Araya, ING. AGR., Geneticist, Santiago Station
Rodolfo González Bueno, M.S., Geneticist, Santiago Station
Luis Del Villar Zarco, M.S., Geneticist, Chillán Station
Hector Wulf Márquez, ING. AGR., Head, Milling and Baking Laboratory, Santiago Station
Oscar Moreno Mucke, ING. AGR., Assistant Geneticist, Santiago Station
Patricio Parodi Pinedo, ING. AGR., Assistant Geneticist, Santiago Station
Juan Acevedo Acevedo, ING. AGR., Assistant Agronomist, Temuco Station
Sergio Rivas Alonso, ING. AGR., Assistant Agronomist, Santiago Station

Iván Correa Opazo, Student in Training, Santiago Station
Jaime Hermosilla Catalán, Student in Training, Santiago Station
Pablo Merino Espiñeira, Student in Training, Santiago Station
Marcelo Valdovinos Salas, Student in Training, Chillán Station

FORAGE AND PASTURE PROGRAM

Donald L. McCune, PH.D., Agronomist, The Rockefeller Foundation
Hiram Grove Valenzuela, M.S., Head, Forage Management Section (on leave)
Mario Rogers Moreno, ING. AGR., Head, Forage Breeding Section
Oscar Cáceres Jorquera, ING. AGR., Acting Head, Forage Management Section, Santiago Station
Jorge Silva Fuentes, M.S., Geneticist, Temuco Station
Talia Gutíérrez Von Hundt, ING. AGR., Geneticist, Osorno Station
Alfredo San Juan Hoyos, ING. AGR., Assistant Geneticist, Chillán Station
Sergio Bonilla Espindola, ING. AGR., Assistant Agronomist, Chillán Station
Hugo Aguila Castro, ING. AGR., Assistant Agronomist, Chillán Station
Fernando Ortiz Silva, ING., AGR., Assistant Agronomist, Osorno Station
Gustavo Cubillos Oyarzo, ING. AGR., Assistant Agronomist, Temuco Station
José Jaime Vicens Obrador, ING. AGR., Assistant Agronomist, Santiago Station (on leave)
Domingo Cerviño Arévalo, ING. AGR., Assistant Agronomist, Santiago Station
Raul Erwin Avendaño Troncoso, ING. AGR., Assistant Geneticist, Santiago Station
Eduardo Riveros Veas, ING. AGR., Assistant Agronomist, Santiago Station
Patricio Azocar Cabrera, ING. AGR., Assistant Agronomist, Santiago Station
Claudio Bariggi Zambra, ING. AGR., Assistant Agronomist, Santiago Station
Arturo Avendaño Besoaín, Student in Training, Santiago Station
Gonzalo Gil Salaya, Student in Training, Santiago Station
Eugenio Munita Valdés, Student in Training, Santiago Station
Juan Obrador Rousseau, Student in Training, Santiago Station

EXPERIMENT STATION OPERATIONS

Arthur D. Leach, PH.D., Associate Agricultural Engineer, The Rockefeller Foundation
Oscar Lillo Valladares, Architect (temporarily assigned to the Office of Special Studies)
Manuel Gómez Maira, Student in Training, Santiago Station
Michael Raczynski Von Oppen, Student in Training, Santiago Station
Edgardo Ossandon Prudent, Student in Training, Santiago Station
Alfonso Salazar Domeyko, Student in Training, Santiago Station

Construction at Central Experiment Station, Santiago.

Director's Introduction

The Chilean Agricultural Program was established in 1955 and is implemented through the Office of Special Studies of the Ministry of Agriculture, a research and training unit jointly staffed and financed by the Government of Chile and The Rockefeller Foundation.

At the time of the establishment of the program, the consumption of agricultural products in Chile was increasing at the rate of 2.3% annually, while agricultural production was going up at the rate of about 1.6%. Though the disparity is less marked now, Chile must still import substantial amounts of wheat, meat, and milk. In the objectives of the cooperative program, priority is given to cereals and forage crops. It would be difficult to exaggerate the potential long-range importance of forage improvement to Chile's agricultural economy. Over 52% of the arable land in the country is in pasture and range; this is about 14 times the amount of land planted to cultivated crops. The potentialities of raising the productivity of this vast area are exceptional.

Work on wheat improvement was begun in May, 1955; work on forage improvement began in April, 1957, and was expanded to include pasture and range management in early 1958. A section on experiment station development and management was instituted in 1959. Four Rockefeller Foundation staff members are assigned to the Chilean Agricultural Program.

The Office of Special Studies has made rapid advances during the past year in each of the three phases of its program. The rate of progress is accelerating as experimental data accumulate and research facilities improve. Local staff has grown to a total of 37 agronomists. Seven of these have studied abroad on Rockefeller Foundations fellowships and 11 more are qualified candidates for future specialized training abroad.

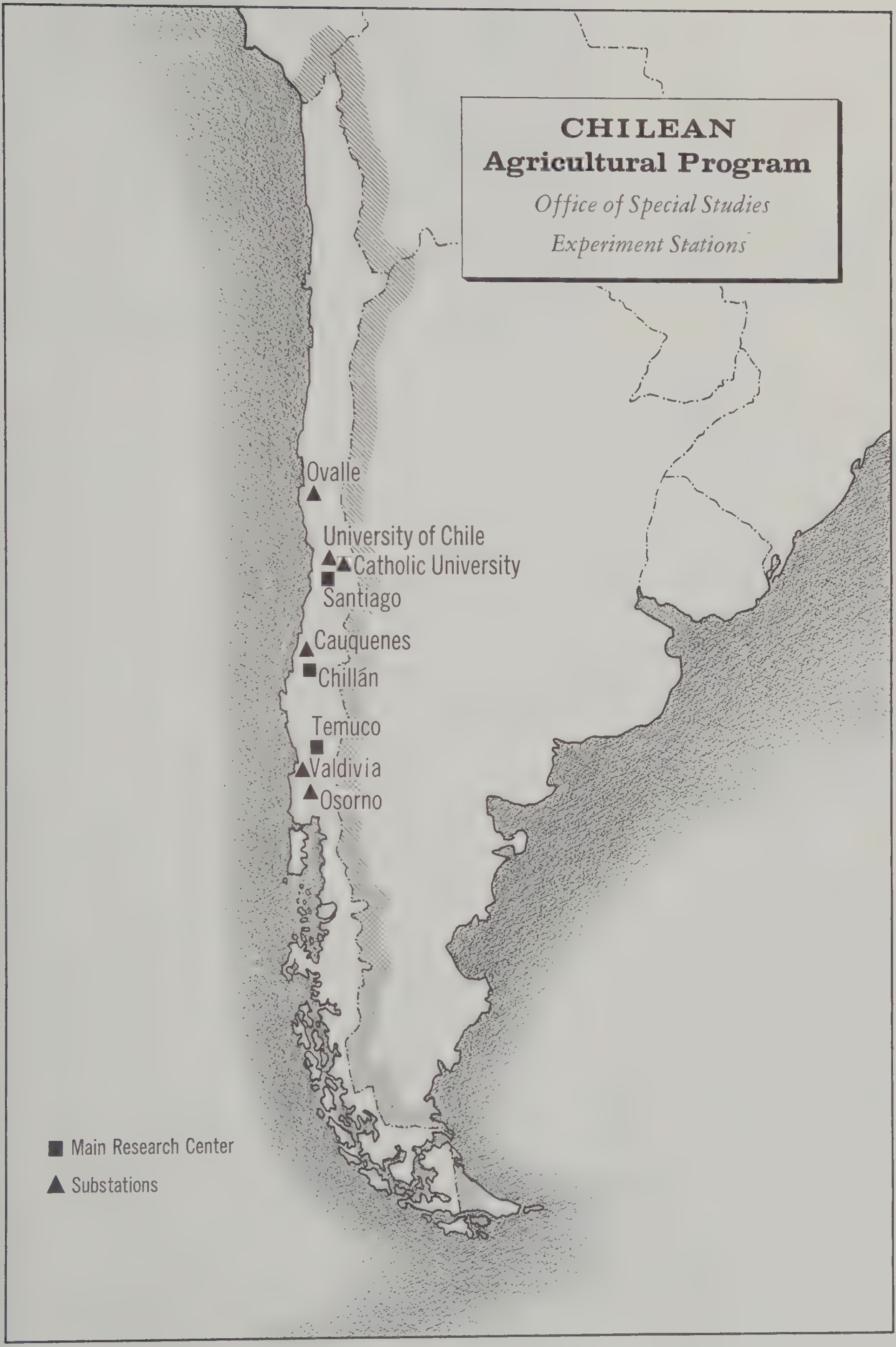
An area of over 50,000 acres of the improved wheat variety Orofén is being planted this season, while the new early-maturing variety Rulofén will be grown for certification on about 1,000 acres. The milling and baking laboratory is in full operation, and it is now possible to identify wheat lines having superior breadmaking properties. Several of these lines, which also yield well, are in preliminary increase.

As a result of the varietal testing of forages during the past two years, productive new strains of alfalfa, subterreanean clover, red clover, white clover, crimson clover, trefoil, ryegrass, *Phalaris*, and sorghum have been selected and are being multiplied, or imported directly from the country of origin. Dr. J. D. Menzies, Temporary Scientific Aide, who studied the problem of alfalfa establishment in the southern half of Chile, found that near-normal stands were obtained when proper inoculants and heavy applications of phosphate fertilizer were used. Successful production of alfalfa in the south would be of inestimable value to the region.

Dr. Kenneth L. Turk spent several months with the program preparing a study of the research needs in the areas of animal nutrition and forage utilization. His comprehensive report will serve as a guide for the initiation in the near future of program activity in this important field.

Major improvements were made at the new experiment stations at Santiago and Temuco. The prefabricated aluminum greenhouses erected at both stations are now in use by the crops sections. Shops and machinery sheds are nearing completion, and it is expected that construction will begin soon on the main laboratory and office buildings. With the valuable collaboration of Temporary Scientific Aide Mr. James Myler, a coordinated network of roads and irrigation-drainage canals was designed, and a method of land levelling within permanent benched borders was adopted.

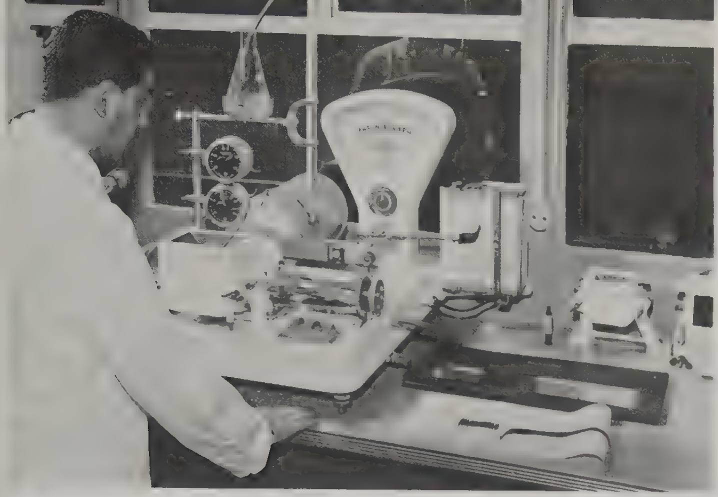
Increasing interest is being shown by both students and professors of the four Schools of Agronomy in the training opportunities presented within the various aspects of the program. During the past year 22 students received some research experience, and a total of 24 thesis studies were guided wholly or in part by OSS personnel.



CHILEAN
Agricultural Program
Office of Special Studies
Experiment Stations

Experiment Stations of the Office of Special Studies, Ministry of Agriculture, Chile, and Cooperating Stations.

	Location	Size (acres)	Altitude (feet)	Av. temp. (°F.)		Av. rainfall (inches)	Principal fields of investigation	Type of agriculture in region served
				Jan.	July			
MINISTRY OF AGRICULTURE STATIONS								
Central Experiment Station	Santiago	753	2,064	69.1	46.4	15.6	Corn, cereals, beans; Forage crops; Oil crops	Crops; Fruit; Livestock; Dairy
Substation	Ovalle	250	797	67.6	52.0	5.1	Cereals	Dryland farming
Substation	Cauquenes	1,500	472	71.8	48.2	28.0	Range management	Dryland farming
Southern Experiment Station	Temuco	555	1,056	62.6	46.0	53.0	Cereals, potatoes; Forage crops; Oil crops; Soil fertility	Crops; Livestock; Dairy (Supplementary irrigation)
Southern Region Substation	Osorno	325	75	63.7	46.7	52.5	Cereals; Forage crops	Crops; Livestock; Dairy
MINISTRY OF AGRICULTURE—UNIVERSITY OF CONCEPCIÓN								
South-Central Experiment Station	Chillán	750	374	71.4	48.4	40.5	Corn, cereals; Forage crops; Animal nutrition	Mixed farming (Supplementary irrigation)
UNIVERSITY STATIONS								
University of Chile	Santiago	3,000	1,476	69.1	46.4	14.3	Corn, cereals, fruit; Forage crops; Dairy science	Mixed farming (Irrigated and dryland)
Catholic University	Santiago	750	2,182	69.1	46.4	19.7	Corn, cereals; Forage crops; Poultry; Dairy science	Mixed farming (Irrigated)
University of the South	Valdivia	375	43	62.8	46.0	99.0	Potatoes; Forage crops	Crops; Livestock; Dairy



Testing bread dough from an experimental variety.

Wheat

New Varieties

The stem-rust resistant variety Orofén, which was released last year, has been well received by the farmers who grew it. With few exceptions, they reported that Orofén yielded more grain than the other varieties on their farms, and yield increases of up to 25% were claimed. Actual yields of from 50 to 80 bushels per acre were recorded in the certified seed campaign. Other characteristics which the farmers liked were its early maturity and resistance to lodging. The Agricultural Bank has produced enough seed of Orofén to sow 50,000 acres this year.

The recently released variety Rulofén will be planted on about 1,000 acres. By virtue of its ability to yield well under dryland conditions, Rulofén is especially suited to non-irrigated areas in the northern wheat zone of Chile. Its resistance to disease, excellent straw, yielding ability, and good quality recommend it for irrigated plantings. Furthermore, its early maturity may make it possible to cultivate row crops on land which produced wheat in the same growing season.

Winter Wheats

Winter wheats are presently cultivated in Chile from the province of Chiloé to the province of Ñuble and account for most of the wheat production in this important grain region. They are not usually grown north of Ñuble, even though suitable climatic conditions may be found in the province of Coquimbo, primarily because the varieties which would be adapted to this region are susceptible to stem rust and consequently do not yield well. Furthermore, the winter wheats tend to mature later than fall-sown spring wheats, and so are not as well suited to dryland farming in this semi-arid zone.

An immediate goal of the wheat improvement program is to develop, through hybridization, winter varieties which might be adapted to cultivation in the northern zone. Several thousand lines of winter wheat hybrids, in which factors for resistance to both stem and leaf rust have been combined with other suitable agronomic characteristics, are in advanced stages of development. Within a short time, selections of the best of these hybrids will enter into comparative yield trials with wheat of spring growth habit.

An even more important objective of the program is to provide better winter varieties for the south. To this end, the backcross method and a convergent improvement method have been used extensively to add factors for disease resistance, better straw, and improved quality to a number of wheats of French origin. The regional varieties Cappelle Desprez and Vilmorin 29 have been used extensively as recurrent parents in this hybridization scheme, to develop higher-yielding varieties of proven adaptation in as short a time as possible. Several thousand lines are now in the nurseries and will soon provide varieties for comparative yield trials.

Altogether, more than 1,000 crosses involving winter wheats were made during the year.

EVALUATION OF INTRODUCTIONS

A continuing phase of the improvement program is the evaluation of introductions. Useful factors were found in a small collection of wheats from Iran and Russia, and several wheats from this group are now being maintained in the crossing block. The International Winter Wheat Rust Nursery, containing 160 entries of varieties and lines developed by programs in the central and eastern states, was also under observation. Although none of the entries in the nursery showed promise of being suitable for use directly as varieties, valuable factors for disease resistance were found and a number of hybrids were selected for use in future crosses.

A world collection of more than 3,800 winter wheat varieties, furnished by the U. S. Department of Agriculture, was tested at Chillán for sources of resistance to stripe rust. About 1,500 of these entries, which showed some form of resistance to the disease, will be tested again to eliminate any varieties which might have escaped the disease and to select the very best sources of resistance. More than 150 varieties from this collection were planted in preliminary yield trials at Chillán, but none proved superior to the regional varieties.

More than 600 varieties from this large collection, which had been selected on the basis of agronomic type after the evaluation of plantings at Temuco and Paine, were again planted at these two stations for further observation. Since all the varieties are extremely susceptible to stem rust, none is directly adapted to the northern wheat zone; a number showed adaptation to the southern zone, however, and will enter into preliminary yield trials. Resistance to leaf rust, stripe rust, and lodging were found in wheats in the group.

Because most of the varieties selected on the basis of agronomic characteristics proved to be of French or Lowland origin, seed of six new French varieties has been requested. These lines will be evaluated for adaptation and disease reaction at Santiago, Chillán, Temuco, and Osorno during the 1960–1961 season.

SPRING WHEATS

About 30% of the total wheat production of Chile is provided by spring wheats. Although these are grown mostly in the northern wheat zone, spring types are raised as far south as Llanquihue. All of the wheat grown under dryland conditions is of spring growth habit.

Many of the spring wheats from the Mexican and Colombian programs have proved to be well adapted in Chile. Eleven hybrids selected for multiplication during 1960 and almost all of the more promising hybrids grown at Paine during 1959 are either direct introductions from these countries or selections from segregating populations originating in them. Data on spring wheats chosen for multiplication appear in Table 1.

More than 300 varieties, from the 1,475 varieties in yield trials in the normal planting, were selected for evaluation during the summer at the new station near Santiago. Since conditions favorable to stem rust occur in this location during the summer, a severe test for resistance to the disease was possible. Sixty of the 300 varieties were found to have an unacceptable reaction, and will no longer continue in yield trials. A number of these otherwise excellent wheats, however, will have factors for disease resistance added to them.

During the period covered by this report, more than 2,000 crosses involving spring wheats were made, to incorporate factors for

TABLE 1.

Performance during 1959 in the central zone of Chile of spring wheats chosen for preliminary multiplication.

Variety or pedigree	REACTION TO Leaf rust	REACTION TO Stem rust	Relative maturity	Quality	Yield[c]
Fr–Fn/Y × 4777	0	0	E[b]	good	139
908 × Fn, A7	S[a]	0	E	fair	133
S–Mt × Gb	0	0	I	good	124
803 × #43	MR	0	E	fair	123
Kt × Fto	S	0	E	good	122
Fn–Y × Kt–#43	0	0	L	fair	120
Fr × McM/Kt–Y	0	MR	I	very good	112
Kt/Bg–Fn/U × Kt–McM/#43	0	R	VE	fair	111
908 × Fn	MR	0	VL	good	110
(K340 × S/Mt–Gb) × K340–Fr	0	0	E	very good	109
Th–StC × My54	0	0	VE	good	108
Orofén (new variety)	S	0	I	fair	108
Menflo (standard check)	MS	S	L	fair	100
Rulofén (new variety)	0	0	E	good	99

[a] R=resistant; MR=moderately resistant; MS=moderately susceptible; S=susceptible.

[b] E=early; I=intermediate; L=late; VE=very early; VL=very late.

[c] Yield expressed in percentage of Menflo, which yielded 62 bushel/acre.

disease resistance with other desirable characteristics. Many of these crosses were combinations with winter types, in a continuation of the attempt to combine the high yields of winter wheats with the disease resistance of spring wheats. It is expected that spring types adapted to the south will be developed as a result of this program.

DURUM WHEATS

Enough durum wheat is grown in Chile to meet the country's present need for semolina products, but any future increase in requirements will have to be filled either by importation or by increased production.

Domestic production, however, is currently threatened by a shift of virulence in the stem-rust population which occurred during the summer of 1959. The predominant durum variety, Candealfén, is now susceptible to a stem rust biotype which exists in Chile. Fortunately, many crosses have been made between Candealfén and varieties which offer sources of resistance to stem rust. A number of these have been backcrosses, using Candealfén as the recurrent parent, and lines from these are in advanced stages of selection. These lines will be tested for resistance to the "new" biotype, and the best ones selected for further increase. Since these lines are essentially Candealfén with added factors for disease resistance, they should be adapted to the durum wheat zone. By planting two consecutive generations in one year, the time lag between a nursery row and a commercial variety will be reduced.

Crosses have also been made with selected wheats to incorporate into Candealfén factors for stiff straw and early maturity. From some of these crosses have come solid-stemmed durum wheats with straw equal to the best in bread wheats. It is still too early to know whether any of these hybrids will serve directly as new varieties, but their outstanding resistance to lodging is a valuable addition to the durum wheat program and they will certainly figure heavily in future crosses between purum wheats.

QUALITY EVALUATION

The results of quality tests conducted during the year on samples of more than 700 entries in yield trials have established the fact that excellent quality for bread can be obtained in wheats grown in Chile.

The test results have aided in evaluating the more promising hybrids in the program and have indicated that a number of the varieties selected for further testing are of good quality. In fact, 18 of the 42 varieties selected for increase in small plots have quality equal to or better than that of the imported flour from North America used as a standard. Further, nine of the 12 varieties in the second stage of multiplication are now known to have better quality than the wheats which are presently grown.

The tests showed too that several of the varieties which were eliminated from further field trials because of their susceptibility to stem rust are worth maintaining for future hybridization. Of these susceptible varieties, four with outstanding quality have entered into a backcrossing project intended to add genes for disease resistance.

An advance of long-term importance in quality investigations has been the standardization of techniques used in the laboratory during the first year of operation so that test results may be readily duplicated.

TRAINING PROGRAM

Seven students received research experience with the cereal program during the past year, in periods ranging from the 2 months of summer vacation to the full 12 months of work experience required for the Ingeniero Agrónomo degree. Two students are now fulfilling the degree requirement with the program.

Eight students are receiving help in the planning, execution, and analysis of their thesis studies. Nearing completion are studies on the inheritance of winter growth habit in wheat, the effect of various chemical and cultural treatments on bunt infection, and results of a fertilizer trial with wheat planted at the two new experiment stations at Temuco and Santiago. The other studies are a herbicide experiment, a date-of-planting experiment, an evaluation of a world oat collection, an investigation of the inheritance of resistance to leaf rust, and a histological study involving stripe rust.

Several demonstrations were held during the year in the field plots for classes from the University of Chile, the Catholic University, and the University of Concepción. Small demonstration plots of wheat were planted on experimental farms of the University of Chile and the Catholic University.

Experimental fertilizing with a grassland drill.

Forage

Although the main effort of the forage program is still directed toward improving production in areas which have adequate moisture, either through irrigation or rainfall, forage research in the arid regions of Chile has been considerably expanded during the past year. It is believed that a significant increase in the forage productivity of the vast dryland area is possible through the use of some varieties which now appear very promising in experimental plantings.

The forage program presently employs 16 agronomists working at 4 regional locations: Santiago, Chillán, Temuco, and Osorno. Outlying trials are also being conducted on a smaller scale at Santo Domingo, Cauquenes, and Valdivia, in order to study varietal adaptation under additional and distinct conditions of soil and climate.

DRYLAND REGIONS

Research in dryland forages was expanded during 1959–1960 to include experiments in three representative climatic areas. In cooperation with the University of Chile, work has been undertaken in the Santiago area under conditions representative of the nearly flat dryland; trials have also been carried out on soils typical of the more hilly dryland areas at the farm of the National Society of Agriculture. Plantings were made on two private farms near Santo Domingo under the conditions of the coastal dryland region, which has a rainfall pattern similar to that of Santiago but a somewhat extended growing season owing to the higher humidity from the sea. The third location chosen for planting is the substation of the Ministry of Agriculture near the city of Cauquenes, located in an area of higher rainfall and on the severely eroded soils so prevalent in this region.

The most productive species in dryland during the past year were alfalfa, subterranean clover, crimson clover, various annual medicagos, berseem clover, ryegrass, Hardinggrass, and tall wheatgrass.

Alfalfa shows special promise for the coastal region, but varieties resistant to leafspot (*Pseudopeziza medicaginis*), downy mildew (*Peronospora trifolii*), and blackstem (*Ascochyta imperfecta*) are needed. Seedling vigor and winter growth were found best in the nonhardy African, Indian, and Moapa varieties, but a spring attack of blackstem caused severe injury. The varieties Peruana and Alta Sierre are more resistant to blackstem, but susceptible to mildew.

Subterranean clover was the most promising forage legume at all locations, especially at Santo Domingo. The comparative yields of the five subterranean clover varieties which proved best in trials at Santo Domingo are given in Table 1. All of the variety trials indicate the superiority of the variety Clare, which has excellent seedling vigor, outstanding yield, and good seed set.

It appears that the variety Clare can be recommended for regions having an average rainfall of over 350 mm. and for coastal regions having at least 300 mm. Seed of this variety is not now commercially available in Chile but 2 tons of Australian seed have been imported by the Ministry of Agriculture for seed increase. For areas with less than 300 mm. of rainfall, the variety Dwalganup is recommended.

Subterranean clover may also have merit in the higher rainfall areas farther to the south. Tests near Osorno indicate that the varieties Clare and Tallarook are equally good, with the choice of variety depending on the period of production desired. Clare grows exceptionally well during the winter months but matures earlier than Tallarook, thus reducing the volume of spring production.

Crimson clover also produces an abundance of good forage under dryland conditions. In trials to date, strains commonly grown in Chile have been superior to imported varieties. However, the variation in yield among the local strains (see Table 2) indicates the need for a certified variety to insure that the grower will obtain seed of the most productive strains.

Berseem clover, a fast-growing, productive annual, also produces well in dryland. It is doubtful, however, whether it will reseed itself. Thus, annual planting is necessary. Berseem clover is proving to be an excellent legume for use in mixtures with cereals, such as forage oats or rye, for winter feeding. Various species of vetch in combination with winter cereals can also be used for this purpose.

TABLE 1.

Yields of five best subterranean clover varieties in trial seeded May, 1959, at Santo Domingo.

Variety	Yield[a]
Clare	46.0
Bacchus Marsh	28.4
Yarloop	23.7
Mt. Barker	21.7
Dwalganup	19.8

[a] Result of two cuttings, expressed in ton/ha. of green weight.

Species mixture trials are being continued. The most satisfactory species to be used in mixtures are subterranean clover, crimson clover, alfalfa, Wimmera ryegrass, Hardinggrass, and tall wheatgrass. On the basis of one year's observation, veldt grass appears promising and will be included in future species mixture trials.

Fertility trials have given promising results at all locations. At Santo Domingo, for example, test plots planted with an alfalfa-Wimmera ryegrass mixture averaged only 5.6

TABLE 2.

Yields of six local crimson clover strains.

Variety	Yield[a]
Common #1	31.6
#2	28.0
#3	28.0
#4	26.6
#5	19.2
#6	7.8

[a] Result of two cuttings, expressed in ton/ha. of green weight.

tons per hectare of green material, while the addition of 60 kg. per hectare of N, 100 kg. of P_2O_5, and 100 kg. of K_2O increased the yield to 19.4 tons per hectare. More studies are needed to determine the economics of fertilizer use under dryland conditions.

Space-planted nurseries of orchardgrass and Hardinggrass have produced some very interesting source material for breeding purposes. Seed has been collected from the superior clones and will be used for progeny testing.

IRRIGATED AND RAINY REGIONS

ALFALFA

The program of alfalfa improvement for the central zone of Chile has consisted primarily of varietal testing. Yield data indicate that a substantial improvement in varieties can be obtained, and over a two-year period increases in yield of up to 17% have been measured, as shown in Table 3, which presents the comparative yields of the six most productive alfalfa varieties in a trial seeded at Santiago in August, 1958. A second trial at Santiago, seeded in September, 1959, indicates that even greater increases in yield can be expected; the yields of eight varieties included in this test are presented in Table 4. The increased yield of the varieties tested is due to two factors: speed of recovery after cutting, and ability to produce during the winter months.

Stem nematodes have been known in Chile for some time but little damage has been reported. A heavy infestation in September and October, however, gave warning that nematode resistance may be very important. Badly infested were the Mexican varieties Oaxaca and Apaseo, along with Southern Common, African, and Moapa. The variety Lahanton was not damaged, but its production is somewhat lower than that of other varieties.

A heavy infestation of leafhoppers severely affected yields in a newly seeded trial. The varieties Israel, Chilean, Peruana, African, and Moapa, however, were not noticeably damaged.

TABLE 3.

Yield of Caliverde in comparison with yields of the six most productive alfalfa varieties in trial seeded August, 1958, at Santiago.

	YIELD	
Variety	Ton/ha.[a]	Percentage of Caliverde
Southern common	227.7	117.1
Moapa	219.7	113.0
Apaseo	219.4	112.8
Oaxaca	216.7	111.4
African	214.5	110.3
Valenciana	214.1	110.1
Caliverde	194.5	100.0

[a] Result of two seasons' harvest, expressed in ton/ha. of green material. Caliverde was cut 10 times; the other varieties were cut 11 times. The extra cut can be expected each year from the nonhardy varieties.

At all locations south of Chillán the results with alfalfa were very inconclusive, and alfalfa yields have been low, mainly because of extremely slow seedling growth and the resulting weed competition. In order to study

TABLE 4.

Yield of Caliverde in comparison with yields of seven other varieties of alfalfa in trial seeded September, 1959, at Santiago.

	YIELD	
Variety	Ton/ha.[a]	Percentage of Caliverde
Israel	68.8	138.3
Chilean (Arizona produced)	61.9	124.8
African	61.4	123.7
Peruvian (Arizona produced)	61.1	122.9
Terra verde	58.8	118.3
Apaseo	55.1	111.1
Moapa	53.6	107.8
Caliverde	49.6	100.0

[a] Result of three cuttings.

this problem in some detail, Dr. James Menzies, plant pathologist and microbiologist from the U. S. Department of Agriculture, has been engaged as a Temporary Scientific Aide for four months. His excellent experiments show that the solution to this problem may be found in a combination of improved inoculum and heavier applications of phosphate fertilizers. The varieties Peruana, Provence, and Du Puits are the best adapted at Chillán (see Table 5) and Du Puits is the best-yielding variety at Temuco and Osorno.

Other phases of the alfalfa improvement program include the evaluation of locally collected clones and a crossing program to obtain a high-producing creeping type of alfalfa for grazing.

RED CLOVER

A locally selected strain of common red clover is now in increase plots for future release to certified seed growers. This strain was selected for its seedling vigor, over-all yield, quick recovery after cutting, and resistance to rust. Although chalcid fly greatly limited seed production during 1960, approximately 10 kg. of seed was harvested and replanted for further increase.

TABLE 5.

Yield of Caliverde compared with yields of four other alfalfa varieties grown at Chillán.

Variety	YIELD Ton/ha.[a]	 Percentage of Caliverde
Peruvian	135.1	115
Provence	132.5	113
Du Puits	126.5	108
Moapa	120.6	103
Caliverde	117.5	100

[a] Green weight resulting from two years of harvest.

Local strains in general have yielded well (see Table 6). The seedling vigor and quick recovery after cutting of the local strains give them a distinct advantage over most imported varieties. Additional selected plants have been placed in a space-plant nursery for individual plant evaluation. Superior individual plants will be used as basic material for new varieties.

Root nematodes have been found to cause damage in at least the Osorno region. This

TABLE 6.

Yield ranking of eight promising red clover varieties grown at five locations over two years.

Variety	Santiago	Chillán	LOCATION Temuco	Valdivia	Osorno
Chimbarongo[a]	1	2	2	4	2
Teno[a]	2	1	1	2	3
Curíco[a]	3	3	4	1	1
Sanford	4	7	15	9	8
Stevens	5	4	8	3	4
Reinhold	6	6	5	12	7
Pennscott	7	5	6	6	5
Kenland	14	14	7	10	16

[a] Native selection.

Resistance to disease and insect damage increases the longevity of stands of red clover lines. Some lines show good resistance after two years of harvest.

presents breeders with another problem to overcome. White fringed beetles (*Graphognatus leucoloma*) seriously injure second-year stands of red clover in most regions. Nevertheless, until the problems of alfalfa establishment are solved, red clover will remain the most popular seeded legume for southern Chile.

WHITE CLOVER

Variety trials of white clover at four locations continue to indicate the superiority of the Ladino type. Comparative yields of white clovers tested at Chillán are presented in Table 7. The results of plantings at Osorno and Valdivia, where severe droughts occurred, indicate that certain Ladino types withstand drought better than most other strains included in the trials. Variation also occurs within the Ladino types, and there is some indication that superior strains can be selected.

The white clovers are very promising pasture legumes for both the northern irrigated regions of Chile and southern areas where severe droughts are uncommon. Its acreage should be greatly increased, since white clover is superior to red clover in these regions.

The fact that no serious disease or insect damages have been noted to date indicates that high resistance is another advantage of white clover.

TABLE 7.

Yields of six white clover varieties at Chillán, 1959–1960.

	YIELD	
Variety	Ton/ha.[a]	Percentage of New Zealand
Caladino M1	33.6	205
Caladino B1	28.2	172
Caladino C1	27.4	167
Caladino 3402	25.7	157
Ladino Bohnert	25.3	154
New Zealand White	16.4	100

[a] Green weight resulting from two cuttings.

TREFOIL

Birdsfoot trefoil (*Lotus corniculatus*) continues to show much promise as a perennial pasture legume for the area south of Temuco. A highly productive strain from Brazil is being multiplied; about 20 kg. have been planted in increase plots. A strain from Argentina, which grows very well in winter in the zones of Valdivia and Osorno, is also being multiplied. Starting with 800 plants transplanted from the greenhouse to the field in September, 1959, over 1,500 gm. of seed was harvested. A comparison is presented in Table 8 of the six best introduced strains of *L. corniculatus* and one strain of *L. tenuis* with local strains of *L. uliginosus*. The latter is productive for only three to four months of the year, but it appears that certain varieties of *L. corniculatus* are productive for at least eight or nine months.

TABLE 8.

Yields of *Lotus* strains the first year after seeding, in 1959, at Osorno.

Variety	Yield (Kg./ha.)[a]
Brazil	9,000
Granger	6,400
Parker	5,750
French	5,330
Douglas	5,100
Viking	4,500
L. tenuis	610
L. uliginosus	145

[a] Green weight resulting from two cuttings.

ORCHARDGRASS

Orchardgrass trials have not shown differences of sufficient magnitude to justify the recommendation of any new varieties. For winter growth and early maturity, the variety Currie from Australia may have some advantages, but its total annual yield is lower than that of the Chilean variety Centifén.

Superior clones from this space-plant nursery of orchardgrass are being used in the formation of polycross varieties.

A space-plant nursery of 425 clones collected in Chile indicates that wide differences occur in flowering date, disease resistance, forage yield, and quality of forage. Based on the different flowering dates, three polycross varieties are being formed from the superior clones. For further testing of the superior clones, open-pollinated seed has been harvested and will be used for progeny testing. Within the past year this nursery has been greatly increased by the addition of plants from the U. S. Department of Agriculture, California, and from collections of the Food and Agriculture Organization of the United Nations.

RYEGRASS

Ryegrass is potentially one of the best winter forages for southern Chile. In general perennial types are preferred over the annuals, but their susceptibility to rust often limits their usefulness. The intermediate-lived Australian variety Short Rotation shows better yields than any of the perennial strains after two years of testing. Some locally selected strains having higher yields are obviously mixtures of annuals and perennials, an indication that a mixture of the annual and the perennial may have some advantage over either one alone.

PHALARIS

Three species of *Phalaris*—*P. tuberosa*, *P. arundinacea*, and *P. coerulescens*—appear to have a place in forage production in Chile. *P. tuberosa* (Hardinggrass) gives an excellent winter growth and is a good producer under irrigation as well as in dryland conditions.

SPECIES MIXTURES

Testing over two years shows that the best-yielding forage mixtures at all locations are those containing red clover. Although the red clover mixtures are beginning to fail with the normal depletion of stand after the second year, a mixture containing red clover is highly recommended for rotations of two years. The grasses which grow best in association with red clover are orchardgrass and ryegrass. Although annual ryegrass is an excellent component in red clover mixtures, it appears that a mixture of annual and perennial ryegrasses may be desirable.

In the Santiago region, for rotations of more than two years, alfalfa alone or alfalfa associated with orchardgrass or Hardinggrass has given the best results. Hardinggrass gives excellent winter growth, but produces little during the summer, making good management of the alfalfa difficult. Ladino clover is always an excellent pasture legume when soil moisture is continuously available. It grows well with orchardgrass, ryegrass, or Hardinggrass.

In the south, where alfalfa is difficult to establish and droughts sometimes eliminate white clover, birdsfoot trefoil (*Lotus corniculatus*) appears to be the best permanent pasture legume. It will be recommended as soon as adequate seed supplies of the Brazilian strain now being multiplied become available. Orchardgrass appears to be the best grass to grow in association with birdsfoot trefoil in droughty soils, and either ryegrass or reed canarygrass is recommended for the wetter areas. For extremely wet soils, a mixture of birdsfoot trefoil and big trefoil (*L. uliginosus*) in combination with reed canarygrass has given the best results.

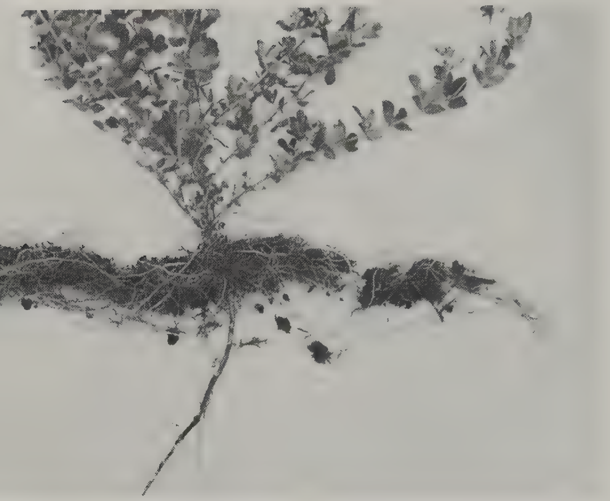
Stands of red clover-orchardgrass-ryegrass mixture obtained by interseeding in corn at the time of the last cultivation.

INTERSEEDING WITH CORN

Two years of experience indicate that forage plantings can be established between corn rows; good stands of red clover, alfalfa, ryegrass, orchardgrass, and rye have been obtained by this method. Wider row-spacing somewhat improves the forage stands, but decreases the yield of corn. Row-spacings of 1½ meters and 2 meters yielded respectively 20% and 30% less than the conventional 1-meter spacing.

SOIL FERTILITY

The need for further soil fertility studies is becoming more and more evident. Under some



Proliferation of root growth within a band of phosphate in deficient soils of southern Chile.

conditions, establishment of forages is impossible without the application of phosphorus. Preliminary trials have also shown the need for nitrogen, sulfur, and potash. Minor element deficiencies are also suspected. Applications of phosphate and nitrogen on a mixture of alfalfa, Ladino clover, and orchardgrass at Chillán doubled the yield. Nitrogen fertilizer on a natural pasture near Valdivia also doubled yields. At Osorno, the application of 60 kg. per hectare of elemental sulfur raised the yield of the first cutting of alfalfa from 4.5 tons green weight per hectare to 6.6 tons, a 47% increase; the quality of the yield was also better. Even though the total yield was small, this response to sulfur is noteworthy.

Although only limited data are now available, it is quite evident that soil fertility studies should be expanded to serve as a basis for work in pasture management.

DATE AND METHOD OF SEEDING

Date- and method-of-seeding studies have been made at all locations for two years but results are still inconclusive. So far, it appears that early fall (March 15 to April 15) and early spring (September 1 to October 15) are the best seeding dates in the south of Chile. Seedings made after April 15 are damaged by winter heaving, except when planted in association with small grains.

It appears that good stands can be obtained in the Santiago region by seeding in April and May, or in August and September, and even later into the summer on irrigated soils. A well-prepared seedbed is essential in this zone to help in controlling the annual weeds.

Band seeding, the placing of the seed over the top of a fertilizer band, has been the most consistently successful method of seeding. This locates the small seedlings in close proximity to the fertilizer—a decided advantage in overcoming weed competition. In one trial near Valdivia, excellent stands were obtained by band seeding, while both broadcast seeding and seeding with the brillion-type seeder were complete failures. Cultipaking after band seeding appears to enhance stand establishment.

GRAZING TRIALS

A grazing trial comparing rotational and continuous grazing on a white clover-ryegrass pasture is being continued at Chillán in cooperation with Dr. Hernán Caballero. No significant differences have yet been observed between these treatments. The lack of sufficient irrigation water during February no doubt injured these pastures, and may have masked differences that would normally have shown up. This trial will be continued for at least another year.

A second grazing trial is being prepared and will be initiated soon. This study will compare two stocking rates on natural and improved pastures in dryland. The improved pasture is now seeded and includes a mixture of subterranean clover and Hardinggrass.

TRAINING PROGRAM

Four students are working in the forage program to fulfill the year of practical training and thesis work required for the Ingeniero

Agrónomo degree. An additional five students worked in the program during the two months of their summer vacation. A total of six theses has been completed and four are nearing completion. Current problems affecting forage production are assigned as thesis subjects. Some of the subjects now under study deal with inoculation of alfalfa and production of improved strains of inoculants, nematode survey and testing for varietal resistance, fertilizer trials in alfalfa using major and minor elements, weed control in alfalfa establishment, interseeding in corn, clipping trials, and methods of seeding. As a rule, these studies are made in the field in order to give the students practical experience in experimental plot techniques.

Research and demonstration plots are maintained at the farms of the four schools of agronomy in Santiago, Chillán, and Valdivia for the purpose of facilitating field training and thesis studies. A great deal of interest on the part of both students and professors has been stimulated through this cooperative activity with the universities.

During the period covered by this report, one scholar from Brazil, Benedicto Rosat Acauan, studied with the Colombian Agricultural Program in the field of pastures and forage crops improvement.

Construction, Central Experiment Station, Santiago.

Experiment Station Development

Under the project agreement signed in April, 1959, the Office of Special Studies is cooperating with the Ministry of Agriculture in the planning and development of two new experiment stations, one near Santiago and the other near Temuco. Work has been under way for one year since the acquisition of these stations and although priority is being given to the Santiago station, equal progress has been made at both locations, since the experience gained at Santiago speeds the operations at Temuco.

CONSTRUCTION

The general layout of the buildings at both stations has been decided upon and a private architectural firm, working with specified floor areas, has designed the administration and laboratory buildings, cafeterias, and greenhouse headhouses. Thus, the detailed building and construction plans for both stations are now complete. Construction will begin at Santiago in the near future; at Temuco, construction on the main buildings cannot be started until October, when the winter rains are over.

The combination farm and carpenter shops and the machinery sheds at both stations have been erected with prefabricated structures available locally, but have not as yet been enclosed. These buildings provide each station with 9,000 square feet for machinery storage, 1,500 square feet for the carpenter shops, and 4,000 square feet for the farm shop and washing and lubrication centers. General warehouses have also been included in the construction plans for both stations; the locations, but not the exact dimensions, of these buildings have been determined.

At both Santiago and Temuco, prefabricated aluminum greenhouses, 35 by 105 feet in size and provided with four isolated compartments, have been erected; although both are incomplete in some respects, they are now being used by the crops research programs. A second identical greenhouse is now under construction at Santiago, and two more have been requisitioned for this station; a second greenhouse has also been requisitioned for the Temuco station.

UTILITIES

At present, the Santiago station has two telephones, limited municipal potable water, and limited electrical power.

An additional 1-inch outlet from the municipal water supply was recently allocated to the station and is being connected to the greenhouse and farm shop. To supply the other buildings, including the future animal buildings, and to provide a small amount of water for irrigation, the Ministry of Agriculture contracted for the drilling of a deep well, which is now under way. This well will be driven approximately 140 meters and is expected to deliver 5 gallons per second. To provide sufficient electric power for an interim period, a 100-kva transformer has been purchased by the Ministry and will be installed in the near future; additional transformers, however, will be required when all projected construction is complete.

Several necessary improvements at the Temuco station have been completed or are planned for the near future. The rural phone line, which extended across the station, has been moved to the edge of the farm; the new arrangement is more convenient and less dangerous for the operation of combines and other large equipment. Sufficient water for all projected buildings will be provided by a deep well, which is to replace the present shallow well. A new power line with 300 kva available for the station is scheduled for completion in August, 1960, and is expected to furnish enough power for all anticipated needs. Until that time, a small generator will be the only source of electric power at the station.

FARM SHOP AND FIELD EQUIPMENT

The field operation was generally hampered during the past year by a lack of tractors and some field equipment, although the Ministry of Agriculture was able to shift temporarily some equipment to the Santiago station for the past six months.

Despite the limited shop equipment on hand, all tractors and equipment received adequate maintenance for continuous operation and a program of preventive maintenance, by which all equipment was given a thorough checkup once a month, has reduced maintenance costs considerably and has kept vehicles on the road more days per month. To minimize the stock of spare parts required, an attempt has been made to standardize tires, filters, trucks, and field equipment.

FIELD OPERATIONS

FIELD IMPROVEMENT

Approximately 4,000 trees, ranging in diameter from 6 inches to 4 feet, have been removed from the Santiago and Temuco stations during the past year. At both stations, several miles of barbed wire fence were removed and at Santiago, an estimated 10,000 cubic yards of stone walls are being cleared and placed in stock piles.

Commercial crops of wheat, alfalfa, corn, and beans, amounting altogether to 300 acres, were planted and harvested during the year.

Surface irrigation is very important at the Santiago station, which receives most of its 14 inches of rain during the four winter months of May, June, July, and August. Irrigation is also important at Temuco, where the summers are often dry.

The Santiago station presented a major problem in land leveling and irrigation, since it has a very thin topsoil, with the most shallow soils usually occurring on the ridges of its gently undulating land. At the Temuco station, the topsoil is somewhat deeper, but only to a maximum extent of 60 inches and to an average of 30 inches.

To assist in solving these problems, Mr. James Myler, Director of Field Stations for the University of California, came to Chile as a Temporary Scientific Aide. Mr. Myler and the agronomists from the Ministry of Agriculture who worked with him decided upon a system of border irrigation as the most practical arrangement for both Santiago and Temuco, and have designed an integrated system of roads, irrigation canals, and drainage for each station.

At the Santiago station, 30 acres have been leveled and borders constructed. Some new permanent canals have been built up to irrigate these border areas, but rainfall is needed for further compaction.

The existing farm pond at Santiago has been cleared of a ten-year accumulation of sand and silt, and now has a capacity of 5,000,000 gallons. The pond was not used during the past year, but will prove useful if the late rains of this year cause a serious shortage of water during the coming growing season (August to March).

At Temuco, a swamp area of about 10 acres was cleared and drained, the exceptionally dry summer weather aiding considerably in this project.

All the roads have been staked and "scratched in" at both stations, although surface material is still lacking.

One third of the Santiago station and one half of the Temuco station were left in summer fallow during the past year for weed control.

The alfalfa which was planted at Santiago was clipped repeatedly to control Johnson-grass, which is a most serious problem. Despite this effort, however, some areas must be plowed up and left in fallow next year because of the intensive growth of Johnson-grass.

To control the very persistent and numerous wild blackberries in the boundaries of both stations, some 2,4,5-T was used. This treatment was effective, but very expensive.

TRAINING PROGRAM

Six students received practical and research experience with the development section during the past year. Two students worked during their two-month summer vacation period; four students are completing the university requirement of a 12-month period of work experience. Two of the four students with the program full-time are working at the Santiago station on theses on border irrigation and land preparation.

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Dr. E. S. Narayanan, Head, Entomology Division
Dr. G. S. Randhawa, Head, Horticulture Division

Dr. R. V. Tamhane, Head, Soil Science and Agricultural Chemistry Division
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Shri Basant Lal Verma, Research Assistant
Shri Bansi Lal Sah, Research Assistant

Arbhavi, Mysore

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(Vacant) Research Assistant

Naraingarh Farm, Punjab

Shri J. N. Batra, Assistant Economic Botanist, Maize
Shri V. P. Sood, Research Assistant
Shri Habir Singh, Research Assistant

Kalimpong, West Bengal

Miss Suva Ghose, Assistant Botanist (until September, 1959)
Shri R. K. Bhattacharya, Assistant Botanist
Shri S. N. Ghosh, Research Assistant
Shri S. S. Mahapatra, Research Assistant

Kangra, Punjab

(Vacant) Assistant Maize Breeder
Shri K. C. Raina, Research Assistant
Shri Harinder Singh, Research Assistant

Pusa, Bihar

Dr. Rameshwar Singh, Maize and Millet Specialist
Shri T. D. Jha, Assistant Maize Breeder
Shri P. N. Sinha, Research Assistant
Shri W. N. Jones, Research Assistant

Ajmer, Rajasthan

Shri D. R. Bhandari, Assistant Maize Breeder
Shri K. L. Vyas, Research Assistant
Miss T. Uma Devi Menon, Research Assistant

Lachung, Sikkim (not in operation)

Namchi, Sikkim, (not in operation)

SORGHUM IMPROVEMENT PROGRAM

Indian Agricultural Research Institute

K. O. Rachie, PH.D., Coordinator, Geneticist and Sorghum Specialist, The Rockefeller Foundation
Dr. C. L. Dhawan, Associate Coordinator (PIRRCOM)
Dr. D. Srinivaschar, Senior Cytogeneticist (PIRRCOM)
A. A. Sheth, PH.D., Technical Assistant (temporary)
J. Seth, PH.D., Technical Associate
Shri J. L. Minocha, Technical Assistant

Rajasthan

Shri B. H. Matai, Head, PIRRCOM Subcenter (Ajmer)

Madhya Pradesh

Shri Bhola Nath, Head, PIRRCOM Subcenter (Gwalior)

Maharashtra

Shri V. N. Bodade, Officer In Charge, PIRRCOM Center (Amraoti)
Shri N. Gangaprasada Rao, Head, PIRRCOM Subcenter (Mohol)

Gujarat

Dr. N. Krishnaswamy, Head, PIRRCOM Center (Surat)
(Vacant) Head, PIRRCOM Subcenter (Junagadh)

Mysore

(Vacant) Head, PIRRCOM Center (Dharesgur)
Shri C. A. Gideon, Head, PIRRCOM Subcenter (Bellary)
(Vacant) Head, PIRRCOM Subcenter (Dharwar)

Installing tile for drainage project, IARI.

Director's Introduction

The Indian Agricultural Program came into legal being in April, 1956, when a memorandum of understanding was signed by the Government of India and The Rockefeller Foundation. The agreement provided for cooperative efforts in developing a postgraduate agricultural training center at the Indian Agricultural Research Institute, New Delhi, and for cereal improvement research work with particular emphasis on hybrid corn, sorghum, and millet. Under this agreement, the two phases of the program—research and postgraduate training—are conducted in close interrelationship. The Foundation has assigned to the program staff members who are specialists in agricultural research and education, and has appropriated funds for certain items of equipment and library materials. The Government of India on its part provides the necessary land and facilities and the budget for local staff and for recurring costs of the program.

The Foundation now has six staff members resident in India and each year has also sent well-known scientists from the United States as temporary staff members who serve as visiting professors at the Post Graduate School and as consultants in the crop improvement work.

The Post Graduate School at the Indian Agricultural Research Institute (IARI), inaugurated in October, 1958, has continued to make steady progress during the past year. The postgraduate faculty was formally constituted through full integration of research and instructional functions and now consists of 16 professors and 46 assistant professors. The student body, at the end of the second trimester of this year, numbered 301 students, of whom 186 were registered for the M.Sc. program, 113 for the Ph.D., and two as non-degree research fellows. Qualifying examinations were completed by 114 of the students admitted during the first year of the school's existence and the first group are expected to present their theses in August. Very gratifying progress has been made in the establishment of high standards of admission and performance.

The Post Graduate Council, which is the final authority on academic matters, was formally constituted during the year. The Field Director has been serving as Acting Dean since September, 1959, but it is anticipated that an Indian will be designated as Dean at an early date. A Health, Residence, and Recreation Committee, with faculty and student representation, has made substantial progress in identifying some of the needs in student living quarters and facilities and has been instrumental in initiating several important improvements.

That the institute should make provisions for junior staff to continue to increase the level of their professional qualifications has been recognized. A limited number of staff members of Class II and below have been given the opportunity of enrolling for postgraduate degree programs on a part-time basis.

The second progress report on the cooperative maize improvement project was prepared and distributed among the project workers and to other interested scientists during the year. A number of inbred lines of maize, many of which have been developed within the Indian program, have been evaluated alone and in topcrosses. These have been identified as having the ability to transmit superior yielding capacity and good grain quality. They can be produced under Indian conditions much more dependably than most of the exotic lines out of dent varieties which had been introduced previously. It is confidently expected that by the end of the current season it will be possible to predict and release maize double crosses for most, if not all, of the maize-growing regions of India. These hybrids will combine good adaptation, high yielding ability, a flint or semi-flint grain type, and good acceptability to the cultivators, and will be made up of lines which can be produced dependably in India. This advance should provide the firm foundation required to launch an intensive program of hybrid maize seed production and distribution to cultivators. Since it is recognized that such a program will require dependable sources and supplies of high-quality seed, plans have been initiated for organizing and establishing corporations for foundation and certified seed production, and for providing the necessary financing, inspection, and control to assure the maintenance of proper standards of quality.

The interest in and concern for similar improvements with sorghum and for intensifying work leading to widespread distribution of improved sorghum varieties and hybrids has increased noticeably during the past year. An intensive project for systematic collection of indigenous sources of germ plasm of the sorghums and millets was begun this year. The material obtained by these field collections has been added to the varieties already under study in the experiment stations in the country and to a large number of introductions from the United States, Mexico, Africa, and other parts of the world. The genetic material so assembled is being studied, evaluated, and used, where feasible, in intensive breeding projects. The detailed field evaluations have been mainly limited thus far to the stations at Delhi and Ajmer. It is planned to add one or more stations in west central or southern India in the near future for intensive evaluation of this material in both the rabi (winter) and the kharif (summer) seasons. Seed for uniform yield trials of both sorghums and millets has been supplied during the past year for tests at 37 stations throughout India. As soon as all the data from these tests can be assembled and evaluated, the second progress report on the sorghum project will be prepared and distributed.

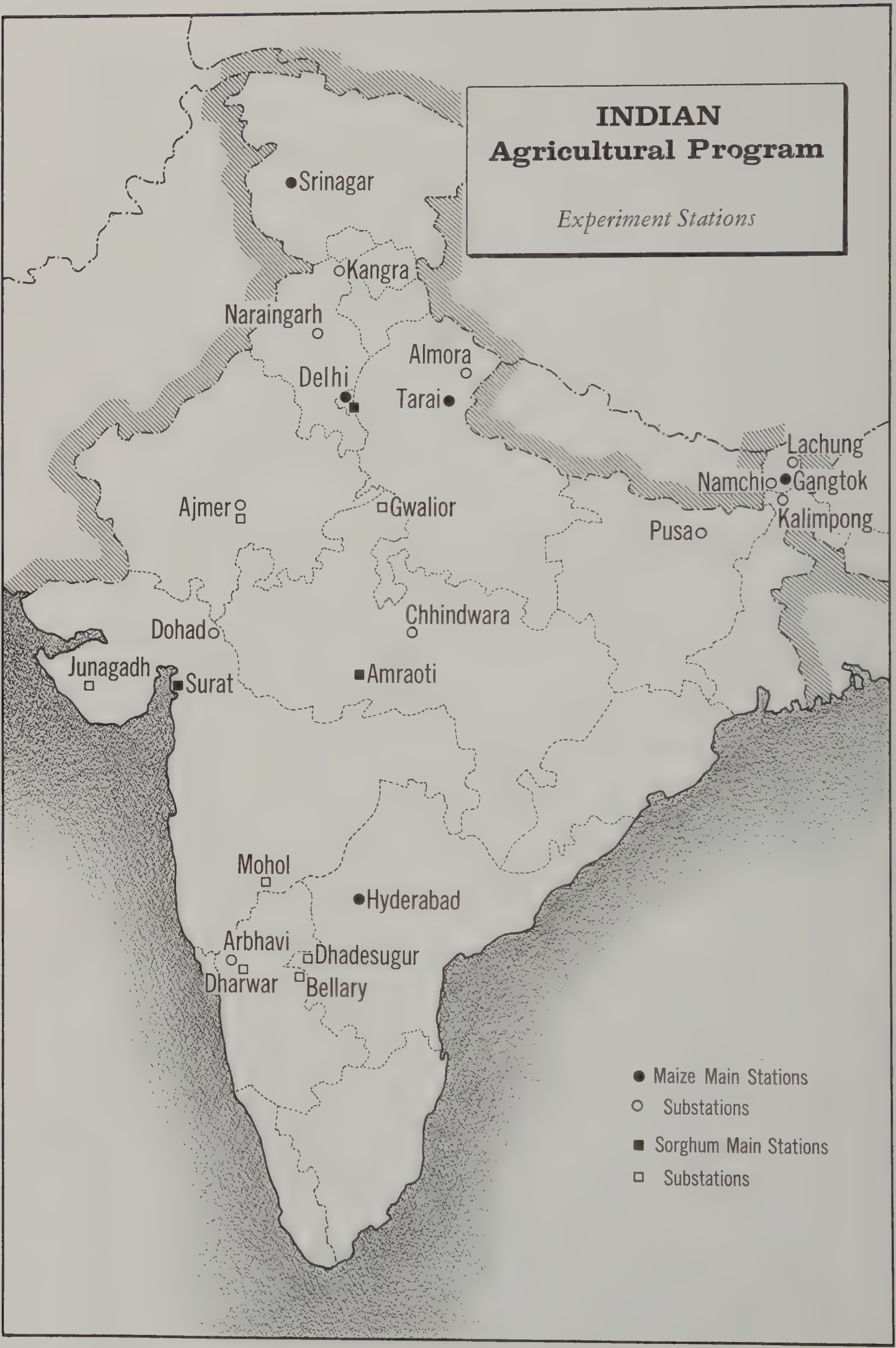
The in-service training program for personnel in the maize project has been quite successful. Seven officers from five stations spent approximately six months (July to December, 1959) at the main center in New Delhi in this program, which consisted of a regular series of lectures, laboratory practical exercises, and experience in the field in all phases of the research and seed production program. Nine of the staff from the cooperative project have been awarded Rockefeller Foundation fellowships for study in the United States.

Plans are now complete and tenders have been accepted for beginning the construction of the cereal research laboratory at the IARI. Progress is also being made on the institute's new library wing, which is very badly needed to provide the required facilities for the research and postgraduate programs. An auditorium and classroom building and a new wing to the Director's office building are now nearing completion.

Dr. Guy B. Baird joined the staff of the Indian Agricultural Program (IAP) as Assistant Field Director during the year, and Mr. J. D. Traywick joined the program as Associate for Experiment Station Operations. Considerable improvement has been made in the facilities for the research projects, particularly in the facilities for storing experimental seed stocks to maintain good viability. The D-4 tractor and bulldozer have been used effectively at Ajmer and Hyderabad in land shaping and land improvement operations. Soil management, water control, salinity control, and drainage are receiving increased attention in the current work.

The IAP has been fortunate in having the assistance, during portions of the past year, of Dr. B. A. Krantz, Extension Soil Specialist, University of California at Davis; Dr. W. M. Myers, Head, Department of Agronomy and Plant Genetics, University of Minnesota; and Mr. R. W. Hodgson, Dean, College of Agriculture and Assistant Director of the Agricultural Experiment Station, University of California at Los Angeles. Dr. Krantz was with the program from June 20 to September 10, 1959, during which period he visited several of the stations where cooperative cereal improvement work is being conducted and made valuable suggestions and recommendations on soil fertility and other soil management problems. Dr. Myers arrived in India on July 9, 1959, and was with the program until the middle of July, 1960. As Visiting Professor of Genetics and Plant Breeding he was closely associated with the Division of Botany at the IARI. In addition to giving invaluable counsel to the cooperative cereal research programs, he was actively engaged as a member of a special committee appointed in the Ministry of Food and Agriculture to prepare working plans for a national seed production and distribution program. Dean Hodgson was in India from July 1 to December 22, 1959. He served as Visiting Professor of Horticulture at the IARI, where he gave valuable aid in developing research and teaching programs.

Dr. Dorothy Parker, who as Library Advisor has been concerned with focusing attention on the requirements for expanding the library at the IARI, left the program in February, 1960, to become Assistant Director for Agricultural Sciences of The Rockefeller Foundation.



INDIAN Agricultural Program

Experiment Stations

Cooperating Federal and State Experiment Stations, Indian Agricultural Program.

Station	Size (acres)	Altitude (feet)	Av. temp. (°F.)		Av. rainfall (inches)	Soil types	Principal fields of investigation
			Max.	Min.			
MAIN STATIONS							
Amraoti, Madhya Pradesh	85	1,213	116.0	41.0	33.52	Black cotton	Sorghum
Delhi, Delhi	1,000	750	115.0	31.0	23.22	Alluvial—Silty	Maize; Sorghum
Gangtok, Sikkim	6	4,500	—	—	150.00	Sandy loam	Maize
Hyderabad, Andhra Pradesh	120	1,760	108.0	56.0	25.27	Sandy loam—Clay loam	Maize
Srinagar, Jammu and Kashmir	—	5,200	95.0	19.0	25.00	Loam	Maize
Surat, Bombay	158	19	100.0	58.0	43.00	Black cotton	Sorghum
Tarai, Uttar Pradesh	16,000	800	110.3	31.8	52.45	Loam—Clay loam	Maize
SUBSTATIONS							
Ajmer, Rajasthan	200	1,595	114.0	27.0	25.00	Sandy loam—Loam	Maize; Sorghum
Almora, Uttar Pradesh	12	4,200	104.0	28.4	50.00	Sandy loam—Clay loam	Maize
Arbhavi, Mysore	15	1,920	108.0	55.0	23.00	Sandy—Sandy loam	Maize
Bellary, Mysore	214	1,460	108.0	52.0	20.00	Black cotton	Sorghum
Chhindwara, Madhya Pradesh	—	2,236	115.0	32.0	39.00	Sandy loam—Clay loam	Maize
Dhadesugur, Andhra Pradesh	322	1,161	108.0	53.0	23.75	Sandy loam	Sorghum
Dharwar, Mysore	800	2,200	104.0	48.0	30.00	Loam	Sorghum
Dohad, Bombay	6	1,001	115.0	40.0	36.00	Sandy loam—Clay loam	Maize
Gwalior, Madhya Pradesh	120	735	116.0	—	29.00	Alluvial	Sorghum
Junagadh, Bombay	450	200	—	—	40.00	Loam	Sorghum
Kalimpong, West Bengal	12	3,500	89.0	44.0	91.75	Sandy loam	Maize
Kangra, Punjab	9	2,195	103.7	44.2	90.00	Clay loam	Maize
Lachung, Sikkim	—	8,500	—	—	60.00	Sandy loam	Maize
Mohol, Bombay	130	1,500	—	—	26.60	Black clay	Sorghum
Namchi, Sikkim	—	5,000	—	—	80.00	Sandy loam	Maize
Naraingarh, Punjab	400	800	115.0	40.0	18.00	Sandy loam	Maize
Pusa, Bihar	1,278	160	113.0	39.2	45.00	Sandy loam—Loam	Maize

Library, Indian Agricultural Research Institute.

Post Graduate School

The Post Graduate School of the Indian Agricultural Research Institute (IARI) has continued to make steady progress during the past year. At the end of the second trimester (April,1960) there were 301 students enrolled: 186 in the M.Sc. program, 113 in the Ph.D. program, and 2 as non-degree research fellows.

The admissions for the second group of students, entering in October, 1959, were granted strictly on the basis of merit. The Post Graduate Council first reviewed the applications for a preliminary screening and, in the final selection, invited over 300 candidates for personal interviews to determine the best qualified group for the quota of 150 admissions. A total of 735 completed applications was screened for the 100 seats in the M.Sc. program, and 384 applications were reviewed in the selection of 50 admissions to the Ph.D. program.

Some delays and uncertainties were inevitably encountered during the first year of operation of the school, but these have, for the most part, been worked out and the program is proceeding smoothly. Advisory committees have been appointed for all students, both first and second year, and in practically all cases the plans for postgraduate work have been developed and approved. Each student has at least two members of his advisory committee from his major field and at least one from a supporting minor field. Ph.D. candidates have at least two advisors from supporting minor fields. The thesis topics have been selected and programs of course work, in all cases, include work both in the major and in minor fields. The course work plans and the constitution of the advisory committees tend to encourage development of programs of training with considerable breadth and to foster an interdisciplinary approach to agricultural research problems.

During the second trimester of the year, 114 second-year students completed their comprehensive qualifying examinations and are now continuing with their thesis projects. The first theses will be presented by the students in August, 1960. The preliminary examinations consisted of written papers, set and evaluated by the members of the advisory committees, and were followed by oral examinations conducted by these committees with one additional outside coopted member. In the case of Ph.D. candidates, the additional committee member was selected from among scientists in the major field, but outside the staff of the Institute.

The postgraduate faculty was formally constituted in September, 1959, and provided for a complete integration of the research and educational functions of the Institute. Each postgraduate faculty member has both teaching and research responsibilities. The present faculty, including the Rockefeller Foundation personnel and selected staff members from the Central Rice Research Institute, Central Potato Research Institute, Central Tobacco Research Institute, and Central Sugarcane Breeding Research Institute, consists of 16 professors and 46 assistant professors.

The Post Graduate Council, consisting at full strength of 15 members, is the body having final authority in academic matters. The Institute Council carried out these functions in developing the plans for the school during its first year of operation. The Post Graduate Council was formally constituted in September, 1959, however, and has been functioning since that time. Its work during the formative year has been quite heavy but a large number of policy and procedural matters have now been placed on a more or less systematic basis. The Field Director has served since September, 1959, as Acting Dean and ex-officio Chairman of the Post Graduate Council. The school, under its authorization and plan of operation, has been able to retain a very useful degree of flexibility and ability to adjust its program in the light of experience.

The importance of providing encouragement and opportunities for staff members of the Institute to improve their professional qualifications is recognized. With this in mind, a plan has been worked out to enable junior staff members (not above Class II officers) to enroll as students of the Post Graduate School on a part-time basis, while continuing in full-time employment.

A Health, Residence, and Recreation Committee, made up of both faculty and student representatives, has been looking into various matters related to student life outside the classrooms and laboratories. These studies have led to the initiation of a number of improvements in the hostels and in recreational facilities and other amenities.

Postgraduate student surveying his thesis material.

An auditorium and classroom building and a new wing for the Director's office building are nearing completion and will substantially improve the facilities for the Post Graduate School. A number of improvements in library services, including more adequate and comfortable reading rooms and an open stack system, are planned but must await the completion of the new library wing before they can be put into effect.

It is anticipated that new Divisions of Agricultural Economics and Extension Training will be added to the Post Graduate School in the near future, with additional staff, buildings, and facilities. At the present time, however, the final sanction is awaited before these plans can be fully implemented.

Cutting channel for tile drains.

Experiment Station Operations

This is the first year that a full-time staff member has been assigned specifically to experiment station operations in the IAP. Considerable time has been spent in evaluating present facilities, operating procedures, and problems. In addition, some studies have been made of the local availability of various machines, spare parts, and construction materials, service on agricultural implements, and mechanics and machinery operators. Information has also been gathered on climatic conditions, power sources, and other factors that influence seed drying and storage, soil preparation, irrigation practices, and other field operations.

SEED PROCESSING

The crop improvement programs in maize and sorghum require facilities for seed processing and storage that have not been available at the various research stations. Owing to the large numbers of small batches of seed produced in the breeding programs, it is difficult to mechanize the processing. However, small-scale threshers and cleaners, hand-operated maize shellers, shellers utilizing either electric motors or tractor power, and moisture testers are used to speed up the operations.

For the Tabiji Research Station, Ajmer, orders have been placed for a portable crop drying unit, a small seed cleaner, and a maize sheller. These items will be installed in the seed-processing building that is scheduled for construction this year.

A number of seed-processing plants designed to handle large volumes of seed have been under construction for some time. The plant at IARI was completed last year and was used on a limited scale this year. The installations of equipment in the buildings at Tarai and Hyderabad are nearing completion and definite plans have been formulated for installing the equipment in the processing building at Gobindgarh, Punjab, as soon as the electrical wiring and bases for the machines are finished. Construction is still under way—with some modifications planned—on the seed-processing building at Padgampora Farm near Srinagar in Kashmir.

The safe storage of seed from season to season and for several years is a particularly serious and difficult problem because of the prevailing seasonal high temperatures and high relative humidities. This year, several additional seed storage rooms have been provided. At the IARI, the prefabricated walk-in cooler for long-term storage has been put into operation with the installation of a larger motor, a thermostat, dehumidifier, and seed racks and trays. A room inside the seed-processing building was constructed for shorter-term, larger-capacity storage and is cooled, when necessary, by two air-conditioners. In addition, two large rooms available to the Botany Division have been equipped for the storage of bulk seed and of plant introduction material by the installation of insulated ceilings, air-conditioners, and dehumidifiers. It is anticipated that seed storage facilities in the cereal research laboratory that is to be built this year will replace some of these temporary provisions.

At the Amberpet station, Hyderabad, a prefabricated walk-in cooler has been erected for seed storage. At Tarai State Farm, plans have been made for a water cooling tower to be used in connection with a 3-ton refrigeration unit provided by the U. S. Technical Cooperation Mission (TCM). This unit will cool a room in the maize laboratory for seed storage space for both TCM and the Coordinated Maize Breeding Scheme. It is anticipated that additional seed storage space will be required at this location next year. Other seed storage facilities include a small air-conditioned and dehumidified room at each of two substations.

Providing long-term seed storage facilities with mechanical equipment is both expensive and uncertain in India because of the unavailability of equipment locally, shortage and frequent failures of electrical power, and equipment repair difficulties. Although results from seed storage research projects throughout the world are not entirely consistent, there is abundant evidence that germination can be preserved for relatively long periods if seeds are stored and kept dry at moderate temperatures.

In an effort to help solve some of the present and anticipated seed storage problems, a series of exploratory research projects is planned. The first project will consist of storing maize seed (and possibly others) in plastic bags and glass jars under a range of initial moisture levels and under different external relative humidities and temperatures. In addition, records are being kept of temperatures and relative humidities within the present seed storage rooms, and periodic seed germination tests will be made.

Information on seed processing in other countries has been collected for the purpose of making recommendations for equipment and structures for foundation seed units and seed production centers in India. In addition, 50-year weather records have been acquired for several representative locations for use in the planning of drying and storage facilities. To keep initial costs low and operation and maintenance problems at a minimum, simple machines and economical, functional structures have been proposed.

LAND SHAPING AND SOIL PREPARATION

Much of the land on which the experimental crops are being grown has already undergone considerable reshaping. Various operations, such as filling gullies, knocking down bunds, leveling of land for irrigation and surface drainage and for the construction of drainage ditches, have been and are being carried out. In addition, green manure crops, maize stalks, and other organic humus-forming materials are being incorporated in the soil in order to increase productivity and improve physical conditions. At most locations, the soil, through past centuries, has been gradually depleted of organic material and this has, in many cases, resulted in poor structure which is unfavorable for plant growth and hampers tillage operations.

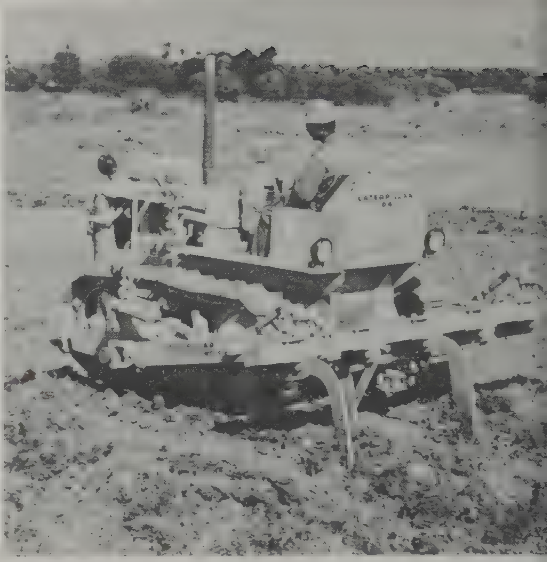
At the Amberpet station, Hyderabad, the Caterpillar D-4 tractor and implements were used for several months this year to reclaim and re-form portions of the station. Also, a large land leveler was taken to this station. Another land leveler has been placed at the Tarai State Farm, where it will be used in the land-shaping operations. For the Tarai station, detailed plans are being formulated for improvements to the land, including removing trees, constructing roads, filling ravines, and shaping the land for surface irrigation and drainage.

Two tractors and some implements have been uncrated and assembled at Srinagar. This year, they are being used at the Aerodrome Farm in the Maize Scheme.

At IARI, through a cooperative research project, a tile drainage system has been designed and installed on 15 acres of maize and sorghum research plots. In addition to gathering general information on the effectiveness of subsurface drain tile under prevailing conditions, the objectives of the project include lowering the water table and correcting the salinity-sodium problems in these fields so that plant material can be more accurately evaluated. Strength tests were made on locally made clay tiles before an order was placed. It is anticipated that information will be obtained which can be used to correct the severe drainage problems of the entire IARI estate and applied to similar conditions that are common throughout the country.

MACHINERY USE AND MAINTENANCE

Considerable attention is required for the proper use and maintenance of the 12 tractors and the large number of motor vehicles and agricultural implements supplied to the various research stations. Because of the shortage of well-trained mechanics and operators and the general unavailability of spare parts in India, this part of the station operation requires much time and care. At present, three driver-mechanics, who have gained experience by working with the Foundation staff members during the past three years, are centrally employed and are available at the various locations to operate specialized machinery and to help train the stations' machinery operators. The training of operators will continue to require major emphasis.


Breaking up hardpan before land shaping.

To facilitate maintenance and repairs of machinery and vehicles and the replacement of consumable items, a storeroom has been established at IARI. Designed to serve all of the mechanized research stations, it contains well-catalogued spare parts, supplies, and unassigned tools and equipment.

Left to right: two new Indian hybrids, a United States hybrid, and a local open-pollinated variety.

Maize Improvement Scheme

Considerable progress has been made by the maize improvement program during the 1959 season, with a number of lines and hybrids performing well in yield trials and a general improvement in the growing and handling of these trials. Improvement also has been made at all stations in physical facilities for conducting the maize breeding program.

In March, 1960, a committee composed of representatives from the various scientific disciplines worked out plans for intensification of research on maize. The committee recommended, for the third five-year plan, that the Indian Council on Agricultural Research (ICAR) establish schemes for research in pathology, entomology, agronomy, and physiology as an integral part of the existing Coordinated Maize Breeding Scheme. Experience during the first years of the Maize Breeding Scheme has demonstrated the urgent need for attention to control of insects and diseases and to improved cultural practices if maize is to become a dependable crop for Indian cultivators and if its production is to be increased.

RESEARCH FACILITIES

Early in 1960, ICAR sanctioned three new stations in Sikkim. One is to function as a main center and the other two as subcenters. Two of these centers are testing material during the 1960 season.

The Srinagar station has expanded with experimental plantings in two locations for 1960. The assistant maize breeder has joined the project, orders have been issued for appointment of the senior maize breeder, and most of the supporting staff have been appointed. Most of the machinery at Srinagar has been assembled. The new buildings at the station are nearing completion, and some will be in use during the 1960 harvest.

Considerable effort has been directed toward improvement of the lands used for experimental purposes. In most areas the plowing under of the maize stalks has helped to improve the general physical condition of the soils. The improved tilth and fertility of the soil have greatly influenced the reliability of the testing programs.

The vigorous plants and well-developed ears of the hybrid on the left in contrast with the open-pollinated variety on the right.

Application of phosphorus to the crop each year has resulted in a build-up of this element in the soils, and the carry-over effect is quite marked in some locations. Of particular significance is the beneficial effect on wheat that follows the experimental maize, as compared with wheat following other crops. In a large portion of the Gangetic Plain, maize and wheat appear to be an ideal rotation.

Salinity and excess sodium continue to be problems and the first steps have been taken to improve the experimental fields where these conditions exist. One field of 7½ acres at the IARI is being tiled and, after application of gypsum, it will be flooded in an effort to accelerate leaching out of accumulated salts. Five acres at Ajmer will also be treated with gypsum at a rate of 2 tons per acre prior to leaching.

Seed storage has received considerable attention during the past year and most of the stations now have seed cabinets and facilities for storing and filing their breeding material. Steps have been taken at several locations to provide facilities and conditions that will permit the storage and maintenance of selected seed stocks for five to ten years.

All stations in the program have been furnished with the essential laboratory and field equipment required for an efficient breeding and testing program.

YIELD TRIAL RESULTS

Yield trial data were obtained in 1959 from 12 locations: Srinagar, Kangra, Almora, Kalimpong, Delhi, Ajmer, Naraingarh, Tarai, Pusa, Hyderabad, Arbhavi, and Dohad. The trials involved 24 different sets of materials in 67 separate yield tests. Topcrosses, U.S. hybrids, French hybrids, Philippine hybrids, single crosses, and experimental double crosses were included in the trials.

TOPCROSS TRIALS

Three topcross trials, with Wf9 × 38–11 as the tester parent, were made at the Tarai center. Eight topcross trials, with Kys × C.I. 21E as the tester parent, were made by the Delhi center with the cooperation of the center at Hyderabad. Three additional topcross trials, with Kys × C.I. 21E as the tester parent, were developed by the Hyderabad center. On the basis of data obtained from trials involving these crosses, approximately 90 lines were selected as superior in combining ability and important agronomic characteristics. These lines were divided into groups of ten and all possible single crosses in each group were made during the last rabi season at Hyderabad. One group of ten was selected for the hilly tract, three groups each for the wet and dry plains, and five groups for the southern zone. These single crosses will be tested in the respective areas in the 1960 kharif season. These 90 lines were developed from 40 varieties originating in 8 different countries: India, Colombia, Peru, Venezuela, Cuba, the United States, Kenya, and Mexico. Thus this material represents germ plasm from a much wider geographical area than contributes to many maize breeding programs.

TRIALS OF U.S. HYBRIDS

Twenty-five U.S. hybrids, representing the various maturity groups, were tested for the third year in 1959 at 12 locations. Of the 12 best hybrids, ranking among the top five at two or more locations, 11 are from the southern region of the United States. Table 1 indicates the locations in which these 12 hybrids have performed well.

In spite of these results, the actual recommendation of any one of these hybrids is not considered advisable because of the general difficulty in propagating the inbred lines and in producing the single crosses involved.

TABLE 1.

Performances of 12 highest ranking of 25 U. S. hybrids tested for the third year in 1959 at 12 stations.

Hybrid	LOCATION											
	Sri.[a]	Alm.	Kan.	Kal.	Del.	Ajm.	Nar.	Tar.	Pus.	Hyd.	Doh.	Arb.
Texas 32	F[b]	F	–	F	F	–	–	F	F	–	F	F
Texas 30	–	F	–	–	F	F	–	–	F	–	F	F
Texas 26	F	–	–	–	–	F	–	F	–	F	–	F
N. C. 27	F	F	F	F	F	–	–	–	–	–	–	–
Dixie 82	–	F	F	–	–	–	F	–	F	–	F	–
Dixie 29	–	–	F	–	F	–	F	–	–	–	F	–
Dixie 28	–	–	–	F	–	–	–	–	F	–	–	F
Dixie 22	–	–	–	–	–	–	F	–	–	F	–	F
Dixie 11	-	–	–	–	–	–	F	F	F	–	–	–
U. S. 523W	F	–	–	–	–	–	–	–	–	–	–	–
U. S. 578	–	–	–	–	–	F	–	F	–	–	–	–
Nebraska 401	–	–	–	–	–	–	–	–	–	F	F	–

[a] The abbreviations, from left to right, refer to these locations: Srinagar, Almora, Kangra, Kalimpong, Delhi, Ajmer, Naraingarh, Tarai, Pusa, Hyderabad, Dohad, and Arbhavi.

[b] F=favorable performance.

EXPERIMENTAL DOUBLE-CROSS TRIALS

Of the four experimental hybrids from Almora which were tested last year, one, (GCL31 × GCL33) × (NC7 × NC13), performed very well at several locations. This hybrid, plus eight new experimental hybrids from Almora, went into a new uniform yield trial for 1960. Three experimental hybrids from Hyderabad also were included in the new uniform trial. Unfortunately, several of the above-mentioned hybrids have lines such as NC7, NC13, Wf9, or 38–11, which have a limited area of adaptation.

Another experimental hybrid, (Kys × C.I. 21E) × (Tex. 325 × Tex. 203), performed very well at most of the locations and appears to have a relatively wide area of adaptation. One challenging goal for maize improvement in India is the development of a hybrid that would have the wide range of usage that US 13 had in the early days of hybrid maize in the United States.

Breeding Program

One of the important features of the Coordinated Maize Breeding Scheme is that germ plasm collected from all over the world has been made available and tested. Table 2 is a list of inbred lines, varieties, and varietal crosses that were grown in the 1959 kharif season in addition to the cooperative yield trials. The rigorous selection carried out in this material on the basis of agronomic performance and topcross yield data has greatly reduced the amount of material to be handled next year. The nursery blocks now show the results of past selection and, except for certain introduced material, lines of very poor quality were seldom encountered in the 1959 season. It is most encouraging and a mark of progress that selection has been so effective, and that lines of increasing superiority have been obtained in each successive season.

Certain lines perform particularly well in a given agroecological zone, while other lines have proven superior in other zones. Selection has enhanced these differences and only the best-performing materials adapted in a given zone are propagated.

TABLE 2.

Numbers of inbred lines and varieties and varietal crosses grown, in addition to cooperative yield trials, during kharif, 1959, at 12 locations.

Location	Number of inbred lines	Number of varieties and varietal crosses
Delhi	1,140	1,228
Tarai	909	834
Hyderabad	1,021	247
Srinagar	50	247
Almora	677	–
Arbhavi	100	–
Dohad	–	220
Naraingarh	665	206
Kalimpong	171	26
Kangra	300	75
Pusa	87	–
Ajmer	172	–

Observations in the breeding nurseries indicate that lines from the corn belt of the United States as a whole appear to do the best at Srinagar; certain of them are fairly good at Hyderabad; and in general they are poor in the northern plains of India. At Srinagar certain varieties and varietal crosses from the United States appear to be outstanding. These are: Jarvis × Indian Chief, Jarvis × Weekly, Yellow Sure Cropper, Lancaster, and others. In general at Srinagar, the South American and the most southern U.S. varieties and varietal crosses show a lack of adaptation. Corn belt lines from the United States that appear promising in this area are: Kys, Ok7, Oh28, Wf9, 187–2, K148, Oh51A, and Hy. Inbred lines Mat. SLP–1–5–2–f–#, Precoz. 115–4–f–f–#–#–#, and Eto Blanco 245–f–# from South America also show promise.

At Hyderabad a number of corn belt and other lines from the United States appear to be well adapted. These are: Kys, Wf9, M14, Ok11, C.I. 21E, M14, and certain other Ohio and Oklahoma lines. The single cross Kys × C.I. 21E has yielded exceptionally well in this area. However, it has been noted that certain lines have shown differential response in the kharif and rabi seasons. Similar seasonal differences have also been noticed among some lines developed in India.

The desirability of setting up a breeding program for each season at Hyderabad may have to be considered and thoroughly explored, since maize is normally grown in both kharif and rabi seasons in southern India. The results of the yield trial tests conducted thus far would serve as a basis for selecting materials with outstanding performance in each season.

The Need for Cooperation With Other Agricultural Sciences

The need for collaboration with specialists in other fields has been strongly emphasized by the maize breeders of the Coordinated Maize Scheme, as a consequence of problems they have encountered during the last three years of operation. In response to this need, a meeting was held at the IARI, where immediate temporary aid was solicited from the Divisions of Mycology and Plant Pathology, Entomology, Agronomy, and Soil Science and Agricultural Chemistry. The breeding group is convinced that appropriate specialists must work in coordination with the Maize Breeding Scheme to study the disease, insect, and agronomic problems if hybrid maize is to achieve full success in India. Work on such problems can be carried out most effectively if the specialists cooperate as a team on hybrid maize improvement. In a cooperative program, the ideas and talents of several individuals are focused on a problem and because of this a better research program results. The cooperating individuals share in the planning and execution of the projects, as well as in publication of results.

Some of the specific problems for which a cooperative approach is considered imperative are discussed in the following paragraphs.

INSECT PESTS

The borer *Chilo zonellus* Swin. is the most destructive insect pest of maize in India. Another borer, *Sesamia* sp., also causes considerable damage. In 1958, 15 acres of yield trials at Delhi were destroyed by *Chilo zonellus*, and in 1959 the trials were severely damaged in spite of a concentrated effort at control with insecticides. There are areas in India, particularly in the northern plains, where farmers have stopped growing maize because of borer damage.

The borers hatch on the leaves or stalks of the young plants and crawl to and cut the growing points, which then die. Such damaged plants generally produce many tillers but very little, if any, grain. When the borer enters the whorl of the plant it is effectively out of reach of chemical control. Chemicals are effective only when they contact the borers during the relatively short time from hatching until entering the whorl. These borers also do damage by leaf-feeding and stalk-boring. At present there is no known satisfactory source of resistance. However, work has been started at the IARI center to evaluate available germ plasm for tolerance to *Chilo zonellus* and *Sesamia* sp. Indications are that a wider collection of germ plasm should be obtained and screened, and that a specialist in the field of entomology will be needed to develop and conduct such tests.

Some of the other insect pests which cause damage to maize are aphids, grasshoppers, a maize beetle, and corn earworms. Aphids are a serious problem to the breeders at times because tassels covered with these insects fail to shed pollen in a normal fashion. Damage by the maize beetle was restricted this last season to certain production fields at Tarai State Farm. The damage to the seedlings was severe since frequently there were five to ten of these insects on one plant. Likewise the corn earworm can inflict heavy damage. The aid of an entomologist is necessary to study measures of control and eradication.

DISEASES OF MAIZE

There are several diseases which cause serious damage to maize. The bacterial rot, *Erwinia carotovora*, has resulted in 20% to 40% damage in certain plantings at the Tarai

State Farm. The disease has also been found at Delhi, Hyderabad, and other locations. The rot affects the node bearing the ear shank, causing chaffy kernels or a rotted ear, and spreads up and down the stalk. There appears to be another closely related bacterial disease which causes the stalk to rot.

Field observations indicate that maize collections show a range in susceptibility to bacterial rot. Therefore it may be possible to find and utilize tolerant or resistant lines. It is believed by the breeders that this disease is a serious problem and that extensive investigations on it should be undertaken.

Helminthosporium leaf blight, possibly *turcicum* and *maydis*, is widespread in India, being exceptionally severe in the Tarai, southern India, and the Himalayan hill areas. There may be other species of this leaf blight active in India. This disease becomes apparent just after flowering and may spread so fast that plants die prematurely. Under very severe conditions the surviving plants fail to set seed. The breeders have noticed variation in susceptibility to this disease and have selected against it, but a more detailed pathological study is needed.

Downy mildew is severe in the northern plains area of India. The plants become chlorotic and dwarfed and fail to produce grain. The disease usually attacks at the seedling stage and will spread rapidly through a field. Control by removing infected plants and by using chemical fungicides has been partially effective. A copper-based fungicide has offered some control at the IARI and Ajmer centers.

Rust in maize is quite severe in the Himalayan area and in southern India. The species of rust causing this damage has not been identified. The disease attacks just after flowering and in severe cases the plant is prematurely killed. The effect on yield is similar to that of a bad epiphytotic of *Helminthosporium*.

There is an unidentified disease which occurs all over India and affects plants in the seedling stage. The tissue at the base of the plant becomes hard and brown; the roots also become brittle and break easily. In extreme cases the plants appear wilted and sometimes die even in wet soil. If sufficient water can be applied the plants generally continue to grow, but the yield is reduced.

Another unidentified disease, which causes large water-soaked lesions and finally drying of the whole leaf, was observed at several locations in India.

AGRONOMIC PROBLEMS

It is anticipated that in the near future improved hybrids will be made available to the Indian cultivators. Information will be needed on rates and kinds of fertilizer, dates of planting, optimum plant populations, weed control, and other cultural practices. The Agronomy Division at the IARI has conducted preliminary experiments on rates of fertilizer application and plant populations.

Some very useful information was obtained by Dr. B. A. Krantz on soils and on water from irrigation wells at several locations where maize trials were being conducted. There was considerable evidence of deficiencies of one or more of the major plant nutrients (nitrogen, phosphorus, and potassium) at most of the locations. It was also confirmed that the sodium hazard in the well water for irrigation at Ajmer was very high.

As a result of field observations, salinity and sodium tests, rapid soil fertility tests, and periodic plant tissue tests, it was possible to make specific recommendations for each location as well as some general recommendations.

From even the limited results now available, it is apparent that many problems exist and will become increasingly important as hybrid maize gains in acreage. It is imperative that more attention be given to the agronomic aspects of maize improvement and production.

TRAINING PROGRAM

The first training course on breeding and seed production for personnel engaged in the Maize Scheme was held during the last six months of 1958. The importance and value of this program has been evident this year at the Hyderabad and Delhi centers and at the

Kalimpong substation. Certain staff members attended the 1958 course and had an opportunity of utilizing their training during the 1959–1960 crop season. As a consequence these stations have made considerable progress.

The trainees participating in the second course in 1959 were: Shri B. P. Pandya, Shri Prithvi Singh, and Shri V. B. S. Khokar, Tarai; Shri R. N. Sangolli, Arbhavi; Shri T. V. Kaushikkar, Dohad; and Shri D. R. Bhandari, Ajmer.

The trainees participated in all aspects of field operations. The fact was particularly emphasized that a breeder must first learn to grow a successful crop before he can proceed to evaluate his breeding material.

In the field, the trainees learned to evaluate inbred lines and yield trials, carried out controlled pollinations, and took the relevant data. This was followed by harvesting, shelling, treating, and storing of experimental seed material. Yield trial data were analyzed by following the requisite statistical procedures.

The program included tours to other maize breeding centers to study the experimental materials in the different agroclimatic zones.

The trainees were also taught the methods of keeping accession registers, maintaining pedigree records, indexing and cataloging experimental seed stocks, and preparing and executing field layouts.

On the theoretical side, a series of lectures on different aspects of maize breeding, genetics, and hybrid seed production were given by experienced technical personnel in the respective disciplines. Agronomic, entomological, and pathological problems, which need solution for the success of the hybrid maize project, were also emphasized in the lecture room and in the field.

Each trainee selected a topic and presented a seminar to the group. Postgraduate students preparing theses on maize at IARI also participated in the lecture portion of the training program.

The trainees participated in a hybrid seed production project which was specially conducted for training purposes. Fifteen acres were planted to the single-cross parents of the hybrid Texas 26, and the trainees were engaged in detasselling and other necessary steps in its production.

Finally, the trainees were given a written test in order to evaluate not only the progress they had made but also the training program itself.

PERSONNEL

There is now a full complement of staff at the main station at Hyderabad and at the substations at Almora, Kalimpong, Pusa, Ajmer, and Naraingarh. As of January 1, 1960, there were 34 research staff members engaged in the Coordinated Maize Breeding Scheme, and 14 vacancies. One year ago, there were 28 research staff members and 20 vacancies. During 1959, 17 people joined the program and 11 left it. Two additional members were added to the staffs at Hyderabad and Pusa, and one additional member each to the staffs at Ajmer, Dohad, Arbhavi, and Srinagar.

While some progress has been made during the period covered by this report, efficiency has been impaired by lack of a full staff, or by frequent changes in the staff, at some locations. A long period of orientation is required before a group can efficiently operate a station. It is therefore of utmost importance that a full staff be placed at each breeding location and that the staff members be kept at the station to form an efficient working team.

Two men, P. S. Bhatnagar and Bagh Singh Sidhu, received their Ph.D. degrees in 1960 from the University of Illinois and Cornell University, respectively. These two men are now working in the Coordinated Maize Breeding Scheme. Dr. Bhatnagar is located at Tarai State Farm and Dr. Singh is at Delhi.

SEED PRODUCTION

The need for more effective means of seed production and distribution for maize and sorghum hybrids, in order to make the results of plant breeding available to the cultivators, has been recognized by officials of the

Government of India. The block seed farms used for increase of varieties of wheat, rice, and other self-pollinated crops are not well suited for production of seed of the cross-pollinated crops.

The Secretary to the Government, Ministry of Food and Agriculture, has appointed a committee to develop plans for improved organization and procedures for production and distribution of seed of new hybrids and varieties. Emphasis will be placed on hybrid maize seed but provision will be made for the inclusion in the program of seed of other crops. The Rockefeller Foundation has been requested to provide technical help in developing the seed program and tentative plans have been outlined, with assistance from Foundation personnel.

The preliminary plans have been approved by the committee and it is anticipated that the Government of India will soon appoint an "Officer on Special Duty" with responsibility for further development and implementation of the seed increase and distribution program.

Collecting rabi sorghum earheads, near Poona.

Sorghum—Millet Improvement

Sorghum and millet improvement provides one of the best opportunities for alleviating India's food grain shortage. These crops are grown on more than 85 million acres, a larger area than is planted to any other single crop. This area includes 41.3 million acres of sorghum and 27.5 million acres of pearl millet. Yields, however, are very low. In 1956–1957, average yields of sorghum and pearl millet were only 403 and 238 pounds of grain per acre, respectively.

The possibility of increasing sorghum yields in India is excellent. Production of the local varieties could be increased by the application of fertilizers, the use of better methods of cultivation, and the control of pests. The maximum yield increases, however, can be achieved only by combining these practices with the use of high-yielding elite strains and hybrids which have tolerance or resistance to pests and diseases and are developed as special types to meet the particular needs of specific localities. If the present yields could be doubled (to 800 pounds per acre, or about half the average yield obtained in the United States in 1958), production would be increased by 8 million tons of food grains, which would more than meet the present food grain shortage in India.

Sorghum is the most important of the millets in India and thus is given primary emphasis in the cooperative program. In order to have high-yielding, high-quality sorghums and to have the high yields realized by the farmers, several objectives will need to be reached: (1) Improved and high-yielding varieties and hybrids will have to be developed to meet the different needs and adapted to the different areas of the country. (2) Effective measures will have to be found for control of the serious insect pests and diseases. (3) Soil, water, and crop management practices, as they relate to the yield of this crop, will have to be evaluated.

GERM PLASM BANK

A large number of millets have been received and are being maintained at the IARI. These include 3,231 collections of sorghums, 618 pennisetums, and 355 minor millets. Most of the sorghums (about 90%) are from Indian sources or are original materials received from

Mexico and the United States. The remainder come from sources of the Food and Agriculture Organization of the United Nations (FAO) or from collections made in Africa during 1959.

The systematic collection of indigenous strains of sorghums, millets, and maize was begun on October 2, 1959. One collection team, by March 31, 1960, had collected in Rajasthan; the southern edge of Punjab; the Indore, Bhopal, and Gwalior Divisions of Madhya Pradesh; and the Poona, Bombay, and Aurangabad Divisions of Bombay State. The numbers of strains of various crops collected include 714 of sorghum, 176 of maize, 130 of pearl millet, and 96 of minor millets.

Materials representing a considerable range of climatic adaptation, maturity, and use, as well as valuable information, were obtained. Methods of growing, processing, and cooking the millets and sorghums in different areas were studied. Certain gross morphological and behavioral characteristics were recorded on individual collections in the field. Detailed head and grain characteristics will be recorded in the matriculation center.

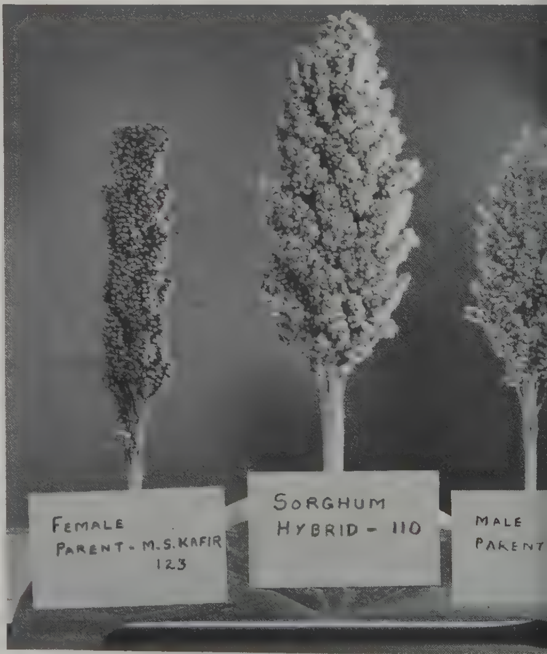
The collections have been stored at IARI for matriculation and field evaluation. The collection will be continued, first in the kharif sorghum-producing regions of Punjab and Uttar Pradesh, and then in the kharif and rabi regions of Bihar, Northern Bombay, and Andhra Pradesh.

Numerous requests for seed have been received from millet specialists in India and abroad. Altogether, 3,418 lots of sorghums, 713 lots of pennisetums, and 286 lots of minor millet seeds have been distributed, of which 77% went to Indian specialists.

New seed storage facilities recently constructed at the IARI will help in maintaining seed viability, and the anticipated establishment of a rabi breeding center will provide a means for propagating short-day-length sensitive varieties. A walk-in cold storage room will be used for a small quantity of seed of each line. A larger room, measuring 18 by 22 feet, has been enclosed, insulated, and provided with dehumidifiers and 1½-ton room air-conditioners to provide for shorter-term storage of frequently used seed, as well as for a limited amount of bulk storage.

PLANT IMPROVEMENT

Extensive breeding and testing programs were conducted at Delhi, Ajmer, and Hyderabad in rabi, 1959–1960. Plantings were much more successful than in the previous season owing to better cultural practices that resulted from experience gained the past year. Land was carefully prepared and properly fertilized, and plantings were made on schedule. Garden seeders proved superior to conventional hand methods in providing for faster seedling growth and greater uniformity of stand. Perhaps the greatest improvement resulted from the rigid schedule of insecticide applications. Sprays and dusts were applied at intervals of from seven to ten days during the first eight weeks of growth. This prevented stem borers and fly maggots from causing extensive damage before the plants were well



Heterosis in sorghums is manifested in faster growth, increased plant size, and larger heads and seed size.

established. Late attacks occurred, but were not as destructive as in 1958.

The 1959 kharif plantings included 1,815 lines at Delhi, 997 lines at Ajmer, and 1,347 lines at Hyderabad. These lines were studied for adaptation and other important characteristics and were also used to provide pollen for test crossing with Male Sterile Kafir 60 and for making intervarietal crosses.

At Delhi, test crosses made during the previous kharif and rabi seasons at Ajmer, Delhi, and Hyderabad were evaluated. A total of 330 test crosses were compared with their parents and standard checks.

At Ajmer, 92 hybrids plus parents and checks were grown in replicated micro trials, and at Hyderabad 235 hybrids were evaluated in rabi sowings. A few test crosses were selected for increase of seed and more extensive testing in 1960. Concurrently a large number of new test crosses were made up for preliminary evaluations in 1960: about 400 crosses at Ajmer, 250 at Delhi, and 210 at Hyderabad.

Several of the test crosses using Indian varieties as pollinators proved quite vigorous and extremely promising. The majority, however, are too late, too tall, have poor-quality grain, or are male sterile. Another difficulty is finding parental lines whose blooming periods are synchronized. For example, otherwise promising test crosses between M. S. Kafir 60 and Aispuri, K–2, Karad, and Satsemari have considerable disparity between blooming dates of the two parents. However, this may not be a serious problem under commercial conditions in India where hand labor could be economically used for staggered plantings. Several of the most promising Indian × M. S. Kafir crosses are male sterile. Some of these may be useful for fodder or as male-sterile females. Other test crosses with the exotic shallus, hegaris, and feteritas produce undesirably colored or soft (chalky) endosperm grain.

Extensive breeding work on pollinators as well as potential male-sterile females will be required to obtain the vigor and quality ultimately desired in hybrid combinations. Nevertheless, the first hybrids are vastly superior to local improved strains and some may warrant immediate commercial production. Several of the more promising hybrids have been increased for extensive testing in 1960–1961, and four of them will be planted in small crossing plots of about ¼ acre each.

Making experimental test crosses between sorghum lines and male-sterile females.

At Delhi and Ajmer, large-scale trials were conducted on grain and fodder sorghums and on pearl millet. At Hyderabad, both kharif and rabi sorghums were tested. Several U. S. sorghum hybrids were included in these trials and, although relatively unadapted and not suited to Indian requirements, they gave the highest grain yields. In the early kharif trial, the three best U. S. hybrid grain sorghums outyielded the three best Indian open-pollinated varieties by 20% at Delhi and 64% at Ajmer. Fodder yields of these exotic dwarf grain hybrids, however, were about half those of the Indian varieties.

Among the exotic open-pollinated varieties, the hegaris and shallus appear promising in northern India. A commercial field of hegari was observed near Alwar, Rajasthan. The farmer growing this variety reported that grain yields tripled and fodder yields doubled those obtained from local varieties. He also claimed the grain was sweet and good to eat in spite of an undesirable brown subcoat. The shallus appear promising because of their superior grain quality, resistance to leaf diseases, open earheads, stalk-borer tolerance, and general adaptability. The disadvantage of using the shallus as pollinators for hybrids is that in combination with M.S. Kafir 60 they produce light brown or buff-colored seeds.

Some of the medium to late varieties have yielded very well in both grain and fodder at Delhi. Tall growing, late varieties have the advantage of better fodder yields if moisture and fertility are adequate and if the land is not required for a second crop.

A large number of intervarietal crosses were made by dusting receptive flowering earheads with appropriate pollen. This method has not proven very satisfactory in preliminary trials, but the technique will be improved and modified. The method of emasculation-pollination will also be used to assure a few seeds of desired crosses.

A sorghum fodder variety grown at the Tarai State Farm.

UNIFORM TESTING

Cooperative uniform trials increased from 9 in 1958–1959 to 63 during the 1959–1960 season. These were carried out at 37 different locations. Yields of grain and fodder, together with other pertinent information, will be analyzed and compiled in the second progress report as soon as all the results have been received from the cooperators. This should be completed by November, 1960.

The recommended methods of conducting the uniform trials will be simplified and improved. Planting rates will be increased to assure an optimum number of plants per plot. In some of the trials, two entries will be left vacant to permit inclusion of local varieties for comparison purposes. The number of trials will be increased in order to group varieties more closely according to type and purpose. The first Indian hybrids will be tested at a limited number of locations in 1960–1961. There will be sufficient seed for full-scale trials with 25 varieties at 6 locations, while micro trials may be conducted at 15 to 20 other locations.

AGRONOMY

In cooperation with the Division of Agronomy of the IARI, a plant population × fertility trial using T.263 (improved Punjab hybrid) was held at Delhi and Ajmer. The experiment at Delhi was partially discarded owing to poor drainage. Borer attack and heavy anthracnose infection affected normal plant development at both locations. General conclusions from this first year indicate that closer row spacings (i.e., 12- or 18-inch versus 36-inch spacings) are probably desirable and that the variety T.263 is not very responsive to higher fertility levels. Similar trials will be repeated in 1960 using, in addition to the best local strain, potentially more responsive varieties, including a high-yielding exotic grain hybrid.

Results of investigations of micronutrient deficiencies in the light, sandy soils of Ajmer were inconclusive. Several micronutrients were tried alone and in combination on a series of crops. These included iron, copper, zinc, boron, magnesium, and manganese, applied as foliage sprays. Magnesium and manganese were also applied in the soil beside the row. Results were complicated by high salinity, possible damage from root-rot organisms, and a heavy infestation of white grubs which occurred in spite of a preplanting application of BHC dust as a soil insecticide. Furthermore, constant and heavier-than-normal rains tended to wash off the micronutrients used in foliage applications. A similar experiment will be carried out in 1960, using soil applications of the same micronutrients.

The control of weeds in experimental plantings of sorghum and millets is an expensive undertaking, particularly during the monsoon season when constant rainy weather severely limits or prohibits the use of tillage equipment. A good pre-emergence weedicide applied immediately after planting could greatly alleviate this problem. Simazine, one of the newer weedicides for this purpose, was tried on sorghum at IARI in 1959 and on sorghum, maize, and pearl millet at Hyderabad during the rabi season of 1959–1960. Preliminary observations indicate that it is very effective against both broad-leaved and grassy weeds but may not control nutgrass at safe or economic levels. Applications of as little as 1 pound of Simazine 50W caused some damage to sorghum at Delhi, while there was no damage at the 2-pound rate at Hyderabad. Further cooperative tests with 2,4-D, Simazine, and Eptam (reported effective against nutgrass) will be carried out by the IARI Agronomy Division in 1960–1961.

ENTOMOLOGY

Experimental sorghum plantings at Delhi in 1959 were heavily damaged by borers and stem maggots in spite of frequent applications of insecticides. Heaviest damage occurred during the late stages of growth, after insecticide applications had been stopped owing to excessive plant growth. Applications of BHC dust were not as effective during the monsoon season as during the relatively dry rabi season at Hyderabad or on early irrigated plantings at Delhi. Three spray applications of endrin, including a sticker-spreader, will be interspersed with dustings of BHC at Delhi during the kharif season, 1960.

Traditional winnowing of threshed rabi sorghum near Parbhani, Bombay.

Evaluations on genetic tolerance or resistance were carried out on 550 lines at Delhi and on 193 lines at Ajmer in replicated plots under natural infestation (without applying insecticides). From the results obtained and from observations made on lines and varieties under trial, it appears that several varieties, including some Indian ones, may have a high degree of natural resistance or tolerance to stalk borers. This promising line of work will be continued in collaboration with the Division of Entomology at the IARI.

BASIC GENETICS

The severe insect and disease problems have warranted consideration and evaluation of the related wild species of sorghums with the objective of transferring resistance or other desirable characteristics into cultivated types. Related species are the para-sorghums having ten chromosomes which include *S. purpureo-sericeum*, *S. versicolor*, *S. Drummondii*, and some forms of *S. nitidum*, as well as the tetraploid (N–40) forms of eu-sorghums including *S. halepense* and *S. almum*. These are difficult to cross and special techniques must be used. This project, however, offers an excellent opportunity for making worth-while cytogenetic and other basic studies. This aspect is being studied in cooperation with the Basic Genetic Wing of the Botany Division, IARI.

TRAINING PROGRAM

Eight technically trained Indian staff members who have attained the degree of M.Sc. or Ph.D. were directly associated with the cooperative sorghum and millet improvement project during the past 12 months. On March 1, 1960, Dr. C. L. Dhawan was appointed Sorghum Botanist (Senior Class I) to serve as Joint Coordinator for Sorghum Improvement in the ICAR "Project for Intensification of Regional Research on Cotton, Oilseeds, and Millets" (PIRRCOM). Six of the remaining staff have entered the Rockefeller Foundation training program on millet improvement for varying periods. Three have obtained appointments in related programs, but all are continuing to participate to some extent in the cooperative project.

The assignment of postgraduate students to the Cooperative Millet Improvement Project provides the opportunity to establish a closer linkage between teaching and research; to work with promising future leaders in India's agriculture; and to carry out some basic studies that have direct implications for the practical breeding program. Four students have been assigned directly to the sorghum project. Two thesis problems dealing with heterosis in sorghums have been assigned. Data have been collected for one of these problems; the second will be started during kharif, 1960, at IARI. The other two students have taken problems in cytogenetics of inter- and intraspecific crosses between sorghums.

FUTURE PLANS
FOR COORDINATED RESEARCH

Substantial progress has been made during the year in developing the coordinated sorghum program. Nine of the 17 main centers and subcenters approved by ICAR for the PIRRCOM scheme have been designated for research on sorghum. Staff for sorghum improvement has been sanctioned for each center; most of these staff members have been selected, and some are already at work.

Recognizing the need for effective coordination of all sorghum research and the potentialities of an accelerated program pointed toward development of hybrids at the earliest possible date, ICAR appointed a committee to plan such a coordinated attack. The committee consisted of representatives of ICAR, sorghum breeders of PIRRCOM, state economic botanists, and The Rockefeller Foundation.

The recommendations of this committee included the following points.

(1) The immediate establishment of two main centers for coordination, intensive breeding and related studies, and provision of test materials to subcenters of PIRRCOM and interested state experiment stations. One main center is the IARI, which is already function-

ing as such. The second main center is to be in the south, where a rabi crop can be grown.

(2) The evaluation of all available collections of sorghum, first in preliminary trials at the main centers and later in trials of the selected materials at appropriate subcenters and state experiment stations.

(3) The adoption of Male Sterile Kafir 60 as the best available female parent for hybrids and the making of test crosses of as many as possible of the available lines and collections with Kafir 60.

(4) The evaluation of the test crosses with Kafir 60 as rapidly as possible, first at the main centers and then at the appropriate subcenters and state experiment stations.

(5) The continuation of breeding programs, primarily at the main centers, to produce better male-sterile parents and better lines for use as male parents of hybrids.

(6) The acceleration of agronomic, entomological, pathological, and other studies related to successful production of sorghum.

ICAR is proceeding, through its PIRRCOM scheme, to provide additional research assistants and field men at the IARI main center for the specific purpose of expanding the test-crossing program with Kafir 60 as recommended by the committee. Indications are that a comparable addition to staff will be made at the southern main center when it is established.

A substantial number of test crosses are to be made at the IARI main center in kharif, 1960, and it is anticipated that the southern main center will be functioning in time for an extensive test-crossing program in rabi, 1960–1961.

Further participation of the Botany, Entomology, Agronomy, and Mycology and Plant Pathology Divisions of IARI in various aspects of the sorghum improvement program is developing as a result of work-planning conferences.

Inter-American Food Crop Improvement Program

Personnel

INTER-AMERICAN FOOD CROP IMPROVEMENT PROGRAM

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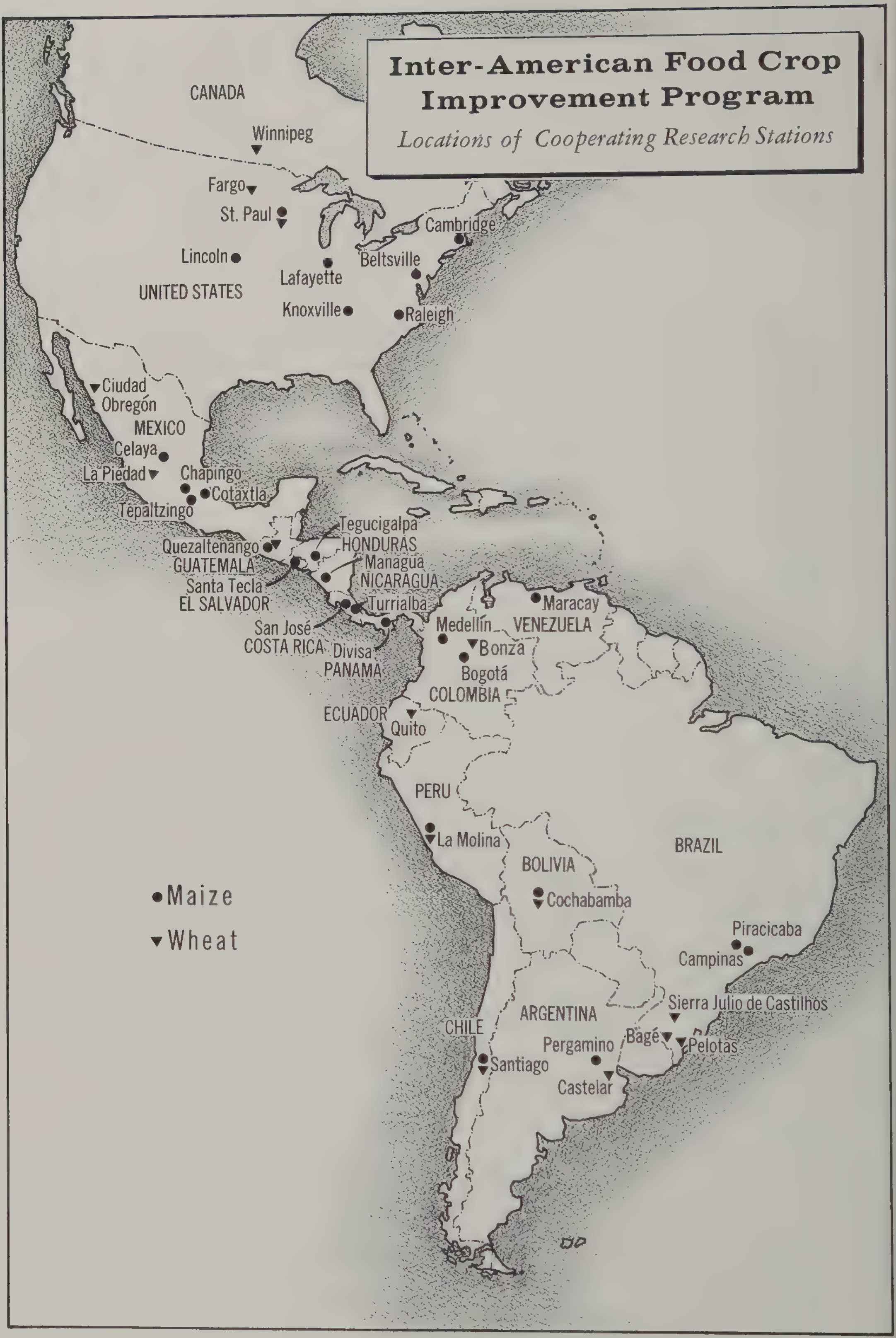
Introduction

The Inter-American Food Crop Improvement Program is a new venture of The Rockefeller Foundation designed to promote the further improvement of the basic food plants in the Western Hemisphere. It is hoped that through this program the accomplishments in crop improvement in the Mexican, Colombian, and Chilean Agricultural Programs can be made more broadly effective through the wider dissemination of the improved varieties, methods of procedure, and experience and knowledge obtained in these programs.

The very successful pattern of operation established in Central America in the cooperative improvement in maize will be broadened and extended to other areas and crops. Greater emphasis will be placed on basic research and on the training of more scientists to work on various phases of crop improvement. Although the major effort in the development of this broader program will continue to be in Latin America, an attempt will be made to initiate certain long-range cooperative basic research projects between North American and Latin American scientists which, as regards maize, may lead to further improvement through a fuller exploitation of the germ plasm reserves in the species for both North and South America.

The Inter-American Wheat Improvement Project evolved naturally from the wheat programs in the Foundation's operating units, which from the first have interchanged materials and information and stressed the training of wheat specialists. The international yield nursery, now being planted at research centers in 15 countries, parallels the International Rust Nursery prepared by the United States Department of Agriculture in 1950 and succeeding years, in which all the Foundation's wheat programs took part. Though still in the early months of its operation, the wheat improvement project, in addition to the yield nursery, has initiated plans for facilitating and encouraging wheat research and training not only in the Western Hemisphere but also in certain other countries where wheat is an important crop.


Inter-American Food Crop Improvement Program

Locations of Cooperating Research Stations

Maize

The maize improvement phase of the broader program is little more than a year old. During the past year, all the major corn breeding and improvement programs in Central and South America were visited and studied with respect to how they might be made more efficient and effective. As a result of this survey, several conclusions became apparent. These may be briefly summarized.

(1) There is a general lack of well-trained, experienced people working in the improvement of corn production.

Although some very good young men are working in the field of corn breeding, their number is quite insufficient to meet the demands of the future. Varietal improvement is only one of the many important factors in the improvement of corn production. Other factors such as soil improvement and control of insect pests and plant diseases are at present receiving little attention. It is evident that before much progress can be expected in substantially increasing corn production throughout Latin America, many more specialists in plant breeding, soil fertility, insect pests, and corn diseases will need to be developed. In places where effective breeding programs have been in progress for a number of years, the resulting improved varieties have clearly demonstrated to the public the value of this kind of work. Local public support for the expansion of activities in breeding and related fields can be obtained about as fast as qualified research workers become available.

(2) Tremendous progress in varietal improvement might be made through the use of exotic germ plasm, or through the exchange of breeding materials.

The collections of corn varieties in the germ plasm banks in Mexico, Colombia, and Brazil are definitely a gold mine for the further improvement of corn in the Americas. The blending of varieties and races offers unlimited opportunities. In many instances, crosses of open-pollinated varieties from different races have yielded as well as or better than many hybrids produced from local material through inbreeding, selection, and recombination of inbred lines. Without doubt there are hundreds of genes for yield, quality, insect and disease resistance, drought resistance, and other important characteristics, about which little is known, in the many different varieties stored in the corn banks. If these genes could be identified, extracted, and brought together, or manipulated more systematically, real super-varieties could be developed for almost any set of conditions. The future offers great opportunities for rapid improvement.

(3) Much more research is needed in the effective use of chemical fertilizers, chemical weed controls, and improved cultural practices.

Good varieties must be better fed, better protected against weeds, and better cared for, if their maximum potential is to be realized. Outside of the Mexican and Colombian Agricultural Programs, little work in these fields is now under way.

(4) Much more research than is now in progress will be needed on methods of control of insect pests and corn diseases.

As yields per unit area are increased through greater investments in fertilizers, weed control, etc., plant protection becomes increasingly important.

(5) There is a hunger for technical guidance and orientation.

Guidance and orientation might best be provided through cooperative research programs. Regional programs patterned after the one in Central America should be developed in other areas as rapidly as possible. Experience gained in Central America will be most useful in the organization of additional cooperative programs.

THE CENTRAL AMERICAN AND OTHER REGIONAL PROGRAMS

The only regional cooperative project at present well established is in Central America.

The progress made in this program during the six years of its operation is a striking example of what can be done when a few trained men are given a little encouragement, leadership, and guidance. Through the cooperative effort of a relatively small group of Central American maize specialists and with the aid of materials, technical assistance, and leadership provided by the Mexican and Colombian Agricultural Programs, improved varieties greatly superior to native ones are now available in all the Central American countries. Some of the improved varieties yield as much as 50% more than the native ones formerly used.

As a result of this accomplishment, a number of government officials in the various Central American republics have become deeply interested in the possibilities of corn improvement and, in many cases, have provided substantial support for the further improvement of this crop in their respective countries. The value of well-trained specialists, and of cooperation among them, has been clearly demonstrated in this area.

The success of the work in varietal improvement is stimulating a similar pattern for experimentation in soil improvement and control of insect pests. This, from a long-range point of view, is perhaps even more important than the improved varieties.

A bulletin on the results obtained in 1958 has been published, and a similar report summarizing results and activities during 1959 is now in preparation. The annual meeting at which results for 1959 were discussed and plans made for 1960, was held February 15–19, 1960, and was sponsored cooperatively by the Ministry of Agriculture of Nicaragua and the inter-American project. The delegates were especially grateful to Dr. J. H. Lonnquist of the University of Nebraska for his excellent review on the formation of synthetic varieties and to Dr. R. J. Laird of the Mexican Agricultural Program for his discussion of the possibilities of improving corn yields through the use of commercial fertilizers.

In the coming crop season, special emphasis will be given to research leading to the formation of better synthetic varieties and to the further improvement of yields through the use of commercial fertilizers. A series of uniform regional experiments designed to determine the fertilizer requirements throughout Central America, have been initiated.

During the past year considerable interest was stimulated in the establishment of a regional program in the Andean zone of South America, comprising Venezuela, Colombia, Ecuador, Peru, and Bolivia. The general problems of corn improvement throughout this area are similar and a great deal can be gained through a cooperative effort. Colombia and Peru are more advanced in their programs than the other countries of the zone and are in a position to furnish useful materials, leadership, and guidance. A very successful meeting was held April 4 to 6 in Medellín, Colombia, with delegates from Colombia, Venezuela, and Peru, to discuss some of the problems and results being obtained in the improvement of corn in Greater Colombia. This was the first step in the initiation of the regional program.

Dr. F. G. Brieger, Director of the Institute of Genetics at Piracicaba, also has been able to make considerable progress toward uniting the corn breeders and geneticists of southern Brazil in a coordinated effort to evaluate the different types of maize in the corn bank at Piracicaba.

Another regional program in the process of formation is one comprising the countries of southern South America: Argentina, Chile, Uruguay, and Paraguay. Of these, Argentina and Chile have the more advanced programs and are in a position to furnish considerable leadership and guidance in the development of a regional program.

Evaluation and Utilization of Exotic Germ Plasm

Although some progress might be made with exotic germ plasm through a more or less haphazard approach, certainly much more can be accomplished for the longer range through a systematic, well planned, well coordinated cooperative effort. During the past year a great deal of consideration has been given to the kind of information most needed and methods of procedure most indicated for the more effective utilization of the material in the corn germ plasm banks. Many of the outstanding corn breeders and geneticists have been consulted on this point.

In March of 1959 a meeting of some of the eminent corn breeders and geneticists of the United States, Mexico, and Colombia was held in Chapingo, Mexico, sponsored jointly by the new Graduate School of Agricultural Sciences and the Inter-American Maize Project, for the purpose of discussing problems involved in the further genetic improvement of corn in the Americas. Scientists present at the meeting, in addition to the leading corn breeders and geneticists of Mexico, were as follows: Drs. G. F. Sprague, John H. Lonnquist, William L. Brown, H. F. Robinson, Oliver E. Nelson, David H. Timothy, and William H. Hatheway.

Previous to this meeting, Dr. H. F. Robinson spent a week in Mexico as a consultant on the type of research that might be most useful. Later in the year, Drs. P. H. Harvey, R. E. Comstock, and Paul C. Mangelsdorf came to Mexico in response to invitations from the Graduate School and the inter-American project to consider the kinds of research needed and the best methods for the development of the super-varieties of the future.

As a result of these discussions, it was decided that the next big advances in varietal improvement might well come through a fuller utilization of the germ plasm reserves manifested by the tremendous variation within the species *Zea mays* L. in the tropics and adjacent areas. To bring about sound and rapid progress toward this end, much additional information is needed. A systematic evaluation and exploration of the full germ plasm reserves in maize and its close relatives, teosinte and *Tripsacum*, must be made. A great deal of basic research will be needed in the identification of superior germ plasm pools.

If the good varieties or races are to be further improved, it must be determined why they are good, what they lack to become better, and where the missing components can be obtained, and how can they be added, to bring about a constant increase in yield capacity.

The problem also involves greater knowledge and better understanding of the true nature of heterosis and other types of gene action in quantitative inheritance in maize. Nature's secrets in the development of some of the outstanding varieties must be revealed. New breeding methods must be developed. Once superior exotic germ plasm has been identified for a certain set of conditions, many problems certainly will be encountered in relation to its use. The nature and magnitude of these problems must be determined and methods devised to overcome them.

RESEARCH AND TRAINING CENTERS

Everyone concerned with the discussions agreed that much of the basic research needed for the further improvement of corn in the Western Hemisphere can best be done cooperatively between United States and Latin American scientists in the Latin American tropics. Ideally, in order to promote such cooperative research and to provide for the training of additional research workers, at least one good international research center for maize should be developed at some strategic place in Latin America, as soon as possible.

In such a center basic research and academic training should be combined. The center would provide a place where a small group of well-qualified scientists could be brought together to work, to learn, to teach, and to do a good share of the needed research with graduate assistants. It could readily serve as a central axis for the coordination of certain kinds of special research and training in Latin America. Furthermore, at such a place, all the corn types of the world could be brought together, their relationships identified, and their value for the further improvement of the commercial varieties studied in collaboration with interested workers in both the North and the South American continents.

Actually, each of the regional programs contemplated for Latin America should eventually have a research and training center dedicated to the training of corn specialists, the accumulation of specific information, and the production of materials needed for a given area. The activities of the regional centers should be closely coordinated with those of the international center. In addition to solving problems pertinent to a region, the centers should participate in the solution of basic problems of importance to all.

A REGIONAL AND INTERNATIONAL CENTER FOR CHAPINGO

Mexico, with the recently established Graduate School at Chapingo, has a great deal to offer for the establishment of a regional research and training center for Middle America. The Republic has a number of capable and experienced personnel, facilities for postgraduate training in genetics, parasitology, and edaphology, and ideal materials for a study of the many problems that need further investigation. Mexico also has many natural "phytotrons" where the experimental material could be studied in its natural habitat and where at least two generations could be obtained per year, with consequent speeding up of the research studies.

A great deal of time and effort this past year has been devoted to strengthening the teaching and research at Chapingo with the objective of developing the Graduate School into an institution that might serve as a local, regional, and inter-American basic research and training center. The center could attempt to solve not only some of Mexico's immediate and long-range problems, but also some of those pertaining to the further improvement of corn in the Western Hemisphere.

BASIC RESEARCH PROJECTS INITIATED AT CHAPINGO

Projects of international importance initiated this past year, which are centered in Mexico and are being conducted in collaboration with the Graduate School at Chapingo, the Office of Special Studies, and with certain experiment stations in the United States and Central and South America, may be classified under the following broad headings:

(1) Identification, origin, and relationship of the varieties and races of maize in the corn bank in Mexico. This is basic to the more complete utilization of the germ plasm in Mexico for the further improvement of maize in this country and elsewhere.

(2) Isolation and evaluation of superior germ plasm for the further improvement of the leading commercial varieties of the Western Hemisphere.

(3) Genetic variance and types of quantitative gene action in some of the principal races of maize in Mexico. The many different types of maize in Mexico would make ideal material for further studies of the nature of hybrid vigor and quantitative gene action.

(4) Nature and magnitude of problems in the use of exotic germ plasm. Once outstanding germ plasm has been isolated, the question is how to integrate it with that which is to be improved. This will need a great deal of study.

(5) Evaluation of breeding methods in the formation of synthetic varieties.

Certain phases of the research outlined above are being advanced as thesis problems in genetics. There are at present seven graduate students working toward a master's degree in genetics at Chapingo. Three of these students will complete requirements by July, 1960. Others will need more time with their research.

RESULTS OF RESEARCH

Although in general the work is very new, significant advances have already been made in certain projects.

(1) Chromosome morphology as a means of determining relationships among races of maize.

Last year Dr. Barbara McClintock spent considerable time in Mexico studying the chromosome constitution of various races of maize from Mexico, Central America, and the West Indies, in collaboration with the Graduate School at Chapingo. This analysis involves the determination of the presence or absence of knobs at the knob-forming regions, their size, shape, stainability, and whether only one or both homologues carry a knob at a specific location. The results were very striking and revealed the extensive degree of mixing of different germ plasms that has occurred within the many regions of this large area.

The relationships among races, as previously determined by morphological, physiological, and genetic characters, were supported by the cytological studies in practically all cases. The flow of introduced germ plasm or the influence of one race in the development of another, was clearly revealed by the distribution of certain kinds of knobs. It is evident from the data obtained that chromosome morphology can be of real value in establishing the broad relationships among races of maize. Once the complete cytological picture of the races of maize in Latin America is obtained, it should be possible to establish the origin of the different germ plasm complexes and trace their flow throughout the Americas in the development of modern varieties.

(2) Identification and classification of the varieties and races of maize in Central America and Panama (outside of Guatemala).

About 75 varieties of maize have now been identified in this area and the collection of data for their detailed description and classification is nearing completion.

(3) Collection, identification, and classification of the modern agricultural varieties in the Caribbean area.

During the period from September to December, 1959, a number of samples of maize were collected from each of the countries in the Caribbean area: Cuba, 25; Puerto Rico, 31; Trinidad, 35; Dominican Republic, 74; St. Vincent; 10; Martinique, 1; Santa Lucia, 5; Tobago, 17; Guadaloupe, 16; Antigua, 8; St. Croix, 7; Haiti, 31; Barbados, 12; Grenada, 17; and Jamaica, 6. These collections, 295 in total, and the collections made earlier by Dr. William L. Brown, are being studied. Data for the preliminary classification of these samples into varieties and races were obtained in the winter breeding nursery planted in January, 1960.

(4) Reduction of material maintained in the corn banks through the formation of composites.

At present over 5,500 viable collections are being stored in the corn bank at Chapingo, Mexico, about an equal number in the bank at Medellín, Colombia, and about 3,000 in the bank at Piracicaba, Brazil. It is virtually impossible to continue the maintenance of all these collections.

In Mexico all of the collections in the bank were planted in the field last year and their characteristics studied for the purpose of compositing collections with the same or similar characteristics. A similar procedure was followed by Dr. Paterniani with the collections in the Brazilian bank and by Dr. L. M. Roberts and associates with the Colombian collections.

The first reduction in the number of collections, therefore, will be through the formation of "varietal composites." Later the populations might be still further reduced by forming racial composites through a system of pyramidal crosses.

The formation of varietal composites for the Mexican bank is now well advanced; the 3,000 collections in the corn bank in Brazil have been reduced to 80 varietal composites. All varietal composites will be increased in areas where they are adapted and a large quantity of seed will be stored under controlled conditions of humidity and temperature for future studies and use.

(5) Cooperative research in the evaluation of germ plasm for the further improvement of maize in the United States and lowland tropical areas of South America.

This summer (1960) a series of crosses between a Corn Belt composite and representative varieties of many of the different races in Mexico are being observed in different experiment stations in the United States.

A series of crosses between the outstanding dent varieties and flint varieties are now ready for evaluation in a uniform test plan in Latin America.

Last winter (1959–1960) in the winter breeding nursery, a large number of crosses were made for the purpose of evaluating the different varieties of the Caribbean in combination with selected varieties and hybrids of the United States, Mexico, Brazil, and Argentina.

Preliminary observations have indicated that the varieties of maize that developed in the Caribbean area will be extremely useful in the further improvement of this crop in the tropics around the world. Seed of these varieties is being widely distributed.

TEMPORARY RESEARCH AND TEACHING AIDES

The research and teaching program in the new Graduate School at Chapingo benefited greatly from the aid of the following scientists during the past year and a half:

(1) P. H. Harvey, Ph.D., Head, Department of Farm Crops, North Carolina State College; Special teaching and research aide in Genetics; March 1–August 31, 1959.

(2) Barbara McClintock, Ph.D., Cytogeneticist, Carnegie Institution of Washington, Cold Spring Harbor, N. Y.; Special Scientific Aide in the determination of chromosome morphology in the races of maize in Mexico and Central America; June 15–August 30, 1959.

(3) C. Clark Cockerham, Ph.D., Professor of Statistics, North Carolina State College; Special teaching aide for an intensive course in population genetics, Graduate School, Chapingo; June 30–August 10, 1960.

(4) Juan Carlos Rossi, Ingeniero Agrónomo, Research Specialist in Maize Improvement, National Institute of Animal and Plant Technology, Pergamino, Argentina; Temporary Scientific Aide in the classification of the maize of Central America and the Caribbean, and its evaluation in the further improvement of maize in Latin America, with special emphasis on Argentina; September 13, 1959–September 13, 1960.

(5) A. E. Longley, Ph.D., Cytogeneticist, Agricultural Research Service, U.S.D.A. —California Institute of Technology; Special Temporary Research Aide in the cytogenetics of maize, Graduate School, Chapingo.

LATIN AMERICAN SCHOLARS

(1) Luis Torres Miranda, Ingeniero Agrónomo; Campinas, Brazil. October, 1959–October, 1960.

(2) Hugo Eduardo Sánchez Campos, Ingeniero Agrónomo; Ministry of Agriculture, Lima, Peru. September 14, 1959–September 14, 1960.

(3) Julio Vargas Méndez, Ingeniero Agrónomo; Head, Department of Agronomy, Agricultural Experiment Station, Tingo María, Peru. October 1–October 30, 1959.

(4) Antonio Sandoval, Perito Agrónomo; National Institute of Plant and Animal Research, Ministry of Agriculture, La Aurora, Guatemala. June 1–July 15, 1960.

(5) Carlos A. Salas, Ingeniero Agrónomo; University of Costa Rica, Agricultural Experiment Station, San Josesito de Alajuela, Costa Rica. July 1–August 10, 1960.

Wheat

The Inter-American Wheat Improvement Project has grown out of several previous activities which were sponsored by The Rockefeller Foundation or in which members of the Foundation staff cooperated.

One of these was the Fourth Latin-American Conference of Agricultural Scientists held in November, 1958, in Santiago, Chile. At this meeting the wheat specialists among the delegates voted to establish a cooperative inter-American yield test. The action resulting from this proposal is detailed below.

Many of these delegates had already had experience with a similar cooperative effort, the International Spring Wheat Rust Nursery, which was established in 1950 under the leadership of the U. S. Department of Agriculture. The international rust nursery has been of tremendous value, both directly and indirectly, to scientists around the world who are engaged in development of rust-resistant varieties. The delegates felt that the setting up of a cooperative spring wheat yield nursery would be of equal or even greater significance for the agronomic improvement of wheat in this region.

For a number of years the wheat specialist of the Colombian Agricultural Program of The Rockefeller Foundation has made periodic visits to agricultural research centers in Ecuador as a consultant to the wheat improvement work in that country. This project has shown that worth-while improvement can result from relatively modest stimulation and encouragement.

Most directly, however, the new inter-American effort has grown from the wheat improvement project of the Mexican Agricultural Program of The Rockefeller Foundation.

The direct benefits from research on various phases of wheat improvement in Mexico have greatly increased national yields and total production. The research contributions of the wheat work have long been recognized by both farmers and government officials; the full importance of the less spectacular training aspects of the program has not been given due emphasis.

In February, 1960, Dr. Ignacio Narvaez Morales, a Mexican scientist, officially assumed full responsibility for the direction of the wheat improvement section of the Office of Special Studies of the Ministry of Agriculture. In this new post Dr. Narvaez will direct the research activities of a team of dedicated, highly trained, experienced, and capable young scientists. These men, and their associates in other sections of the Office, are the most important product of the Mexican Agricultural Program.

The achievement of this final goal of the Foundation's Mexican wheat project—the transfer of scientific leadership to well-qualified Mexican scientists—indicates clearly the time factor that must be taken into account in aiding a country to modernize its agriculture. The attainment of the goal in Mexico represents 17 years of continuous search for outstanding young scientific talent. For each of the young men, it represents from five to seven years of practical research training and experience after graduation from professional school and at least five years of additional formal advanced study.

Although 17 years may seem to be an exceedingly long period for the training of a team of agricultural scientists, it does not appear likely that it can be much reduced in countries where there is a shortage of scientific personnel. One must remember that from time to time it is necessary to divert some of the very best scientific talent from crop improvement research to faculty positions in agricultural colleges and to key positions in other government services where such talent and training are also urgently needed.

When the transfer of leadership for the wheat improvement project to Mexican scientists was in prospect, The Rockefeller Foundation, on the basis of the precedents and proposals mentioned above, began exploring the possibilities of providing technical assistance and guidance for wheat improvement on an inter-American scale.

During 1959 the director of the inter-American project visited and reviewed the wheat research centers in Mexico, Colombia, Ecuador, Peru, Chile, and Argentina, to obtain orientation for the expanded program. During the fall of 1960 the wheat centers in Brazil, Uruguay, Paraguay, Bolivia, and Guatemala will be visited. These visits also aid in laying the basis for the inter-American yield trials.

During the early months of 1960 the director, on temporary assignment to the Food and Agriculture Organization (FAO) of the United Nations, visited the wheat improvement programs of the Near and Middle East countries. This survey also indicated a great need for the establishment of uniform cooperative yield tests in this region.

The Inter-American Yield Tests

Wheat as a crop is grown over an extremely wide range of climatic and soil conditions. It is grown commercially from latitudes of more than 60° North in Siberia, Alaska, Canada, and Scandinavia, to more than 40° South in Chile and New Zealand. Even in the equatorial zone it is produced in those areas where elevation compensates for latitude in maintaining temperate climatic conditions. Much of the flexibility which permits wheat to adapt over so broad a set of conditions results from the great diversification of varieties and forms of the wheat plant.

For many years it has been recognized that certain wheat varieties—Mentana is an example—have wide patterns of adaptation, whereas others are quite limited. Nevertheless, almost no serious effort has been made to evaluate experimentally the relative adaptability of a uniform set of varieties of different origins by growing and observing them systematically under widely different conditions of climate, soil, and latitude. The possibility of developing varieties with extremely wide patterns of adaptation has both theoretical and practical implications of great importance.

The first step toward achieving this objective is the establishment of a widespread uniform yield test, containing 25 wheat varieties selected to represent the most important commercial varieties and the most promising breeding materials of spring wheats from North and South America. During the winter of 1959–1960 seed of the 25 varieties was increased under irrigation at the Foundation's experiment station in Ciudad Obregón, Sonora, Mexico. Twenty sets of seed packets of the 25 varieties were then prepared from this seed, and shipped to collaborating scientists in the following countries: Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, Guatemala, Peru, and the United States of America. Sets were also sent to Australia, Egypt, Pakistan, and Jordan. These uniform nurseries have been grown or are now growing in all these countries.

Collaborators in each country will record notes on yield, agronomic characteristics, and disease resistance, and these will be consolidated and made available to the collaborators and other interested wheat breeders.

Adaptation of Foundation Program Wheats in Other Countries

During the past ten years several wheat varieties bred in Mexico and Colombia have been introduced and grown successfully in Guatemala, Ecuador, Bolivia, Paraguay, and Chile. This again emphasizes the possibility of utilizing potentially valuable breeding materials from the Mexican, Colombian, and Chilean Agricultural Programs of The Rockefeller Foundation in other parts of the world. The establishment of the uniform yield nursery is a further step toward this goal.

In recent years the wheat improvement sections of the Foundation's agricultural programs in the three Latin American countries have sent a large amount of breeding material to other countries. In some instances this material has been furnished directly to scientists working in those countries; in others it has been furnished through intermediary international agencies such as FAO and the International Cooperation Administration of the United States. As a result, several lines that originated in the Mexican program are now being grown commercially or being increased for release in such widely different areas as Kenya, Jordan, Israel, and Libya.

Many of the spring wheat lines and varieties from the Mexican and Colombian programs seem to be well adapted in Libya, Egypt, Jordan, Lebanon, and Pakistan. Lines from the Chilean winter wheat project show promise as commercial varieties in Afghanistan and Turkey. These impressions were gained by the director of the inter-American wheat project on the visit to the Near and Middle East already mentioned, to review the wheat program of FAO in that area.

Many of these materials may be of value commercially, but before this can be determined it will be necessary to establish and expand a system of uniform varietal testing throughout these regions.

The broad adaptation of the materials in the Mexican and Colombian programs appears to be derived from the three "germ plasm complexes," namely: (1) material derived from Mentana (i.e., Lerma, Kentana, and their derivatives); (2) material derived from Florence-Aurore (i.e., Yaqui 48 and Mayo 48, and their derivatives); and (3) materials derived from Gabo (i.e., Gabo 54, Gabo 56, Cajeme 60, and their derivatives). The three varieties referred to, namely Mentana, Florence-Aurore, and Gabo, have each entered into many different crosses in the aforementioned programs. The "germ plasm complex" created by each of these varieties in many different crosses shows many derivatives with very broad adaptation.

On the basis of the broad adaptation of Mexican and Colombian materials throughout the Near and Middle East, the scientists of The Rockefeller Foundation working on wheat improvement are now exploring the possibility and advisability of organizing a second cooperative international spring wheat yield nursery that would be grown in the Near and Middle East, i.e., India, Pakistan, the United Arab Republic (northern and southern zones), Jordan, Lebanon, Libya, Kenya, and Iraq, as well as in Colombia, Mexico, and Australia. The varieties to be included in this nursery, if it is established, will include the principal commercial varieties of these two very different parts of the world, as well as outstanding lines from the breeding programs in each of these regions. Next year the Cooperative Inter-American Spring Wheat Yield Nursery (1960) will be grown in Pakistan, Egypt, and Kenya, to obtain some preliminary information on the adaptation of American varieties in the Near and Middle East, and vice versa.

The Near East-American yield test will be a joint undertaking of FAO and The Rockefeller Foundation.

BASIC RESEARCH ON WHEAT

A number of basic research projects on wheat are now under way in Mexico. These include: (1) studies to develop satisfactory micro-methods for evaluating grain and gluten quality in early generations and using these results to predict quality characteristics in advanced generations; (2) studies to develop methods for transferring the dwarf condition from the bread wheat varieties to durum or spaghetti wheats; (3) physiologic and genetic studies which will result in better understanding of the true nature of "brown necrosis" in certain wheat varieties; (4) studies of rust-race epidemics in mixed and pure-line populations.

PUBLICATIONS 1959–1960

AID TO RESEARCH AND TEACHING

FELLOWSHIP, SCHOLARSHIP, AND TRAINING AWARDS

Publications 1959-1960

MEXICAN AGRICULTURAL PROGRAM

Corn and Sorghum

Carballo Q., Alfredo. Labores desarrolladas durante 1958 en el programa cooperativo centroamericano del mejoramiento del maíz. *Mejoramiento del Maíz—Proyecto Cooperativo Centroamericano: Quinta Reunión Centroamericana.* Paama. March, 1959. (Published in 1960).

Johnson, Elmer, William R. Young, Reggie J. Laird, and Pedro Reyes C. Cómo cosechar 4 toneladas de maíz por hectárea: 7 pasos seguros para alcanzar éxito. *Circular Cotaxtla* No. 4. May, 1959. (Revised and reprinted April, 1960).

Neve V., Jesús, Juan Antonio Sifuentes, and Nicolás Sánchez D. El maíz, su cultivo en el Valle del Yaqui. *Circular CIANO* No. 3. July, 1958. (Revised and reprinted March, 1960).

Osler, Robert D. Mejoramiento de maíz en el programa cooperativo de la América Central. *Mejoramiento del Maíz—Proyecto Cooperativo Centroamericano: Quinta Reunión Centroamericana.* Panama. March, 1959. (Published in 1960).

Osler, R. D. and E. C. Johnson. Studies among races of corn in Mexico. *Maize Genetics Cooperation Newsletter* 33: 112-113. 1959.

Osler, R. D. and E. C. Johnson. Sorghum improvement in Mexico. *Sorghum Newsletter* 2: 60-61. 1959.

Osler, Robert D., Reggie J. Laird, and Douglas Barnes. Aumente su producción de maíz: recomendaciones para El Bajío y regiones similares. *Boletín de Extensión Agrícola* No. 229. June, 1957. (Revised and reprinted February, 1960).

Osler, Robert D. and Gilberto Palacios. El valor de la selección visual entre mazorcas autofecundadas y las de polinización libre. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Reyes C., Pedro and Elmer Johnson. Efecto del deshoje del maíz en el desespigamiento. *Agricultura Técnica en México* No. 8. Summer, 1959.

Wellhausen, E. J. Colección, identificación y evaluación de maíces criollos en la América Central. *Mejoramiento del Maíz—Proyecto Cooperativo Centroamericano: Quinta Reunión Centroamericana.* Panama. March, 1959. (Published in 1960).

Wing M., Marco Antonio. Dos cosechas de sorgo con una sola siembra. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Papers Presented

Johnson, E. C. and R. D. Osler. Combining ability between corn races from the Mexican tropics and others of diverse origins. *Agronomy Abstracts* p. 60. 1959.

Johnson, E. C. and R. D. Osler. Resistance to ear and tassel smut in Mexico. *Maize Genetics Cooperation Newsletter* 33: 113. 1959.

Osler, R. D. and E. C. Johnson. A comparison of six types of testers for evaluation of S_1 and derived S_6 lines. *Agronomy Abstracts* p. 63. 1959.

Wheat and Barley

Borlaug, Norman E., Ignacio Narváez M., Manuel García A., Reggie J. Laird, William R. Young, José Rodríguez Vallejo, and Adolfo Fernández S. Recomendaciones para el cultivo de trigo en los Valles Altos de la Mesa Central y del Norte de México. *Boletín de Extensión Agrícola* No. 325. 1959-1960 Series.

Borlaug, Norman E., Ignacio Narváez M., Gregorio Vázquez G., Reggie J. Laird, William R. Young, José Rodríguez Vallejo, and Adolfo Fernández. Recomendaciones para el cultivo de trigo en la Región del Bajío. *Boletín de Extensión Agrícola* No. 326. 1959-1960 Series.

Borlaug, Norman E., Ignacio Narváez M.,

Gregorio Vázquez G., José Rodríguez Vallejo, Héctor Porras H., and Adolfo Fernández S. Recomendaciones para el cultivo de trigo en la Comarca Lagunera. *Boletín de Extensión Agrícola* No. 328. 1959-1960 Series.

García S., Alfredo and Manuel Navarro F. Progresos en el mejoramiento de la cebada en México. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

García S., Alfredo, Nicolás Sánchez D., Norman E. Borlaug, Ignacio Narváez, Juan A. Sifuentes, José Rodríguez Vallejo, and Adolfo Fernández. Recomendaciones para el cultivo de trigo en la Costa Noroeste del Pacífico. *Boletín de Extensión Agrícola* No. 327. 1959-1960 Series.

Narváez M., Ignacio, Gregorio Vázquez G., and Manuel Navarro F. La cebada produce bien en El Bajío: recomendaciones. *Boletín de Extensión Agrícola* No. 331. 1959-1960 Series.

Beans and Soybeans

Martínez, Eugenio, Celio Barriga, and Juan Antonio Sifuentes. La soya, su cultivo en el Noroeste. *Circular CIANO* No. 9. February, 1960.

Miranda C., Salvador. Thesis. Estudio biosistemático para definir el fenómeno de infiltración genética entre *Phaseolus coccineus* L. y *Phaseolus vulgaris* L. Escuela Nacional de Agricultura, Chapingo, Mexico. 1959.

Patiño, G. and W. J. Zaumeyer. A new strain of tobacco streak virus from peas. *Phytopathology* 49: 43-48. 1959.

Yerkes, William D., Jr., Alfonso Crispín M., and Douglas Barnes. Enfermedades y plagas del frijol en México. *Folleto de Divulgación* No. 29. June, 1959.

Yerkes, W. D., Jr., Alfonso Crispín M., and Francisco Cárdenas R. Aumente su producción de frijol. *Boletín de Extensión Agrícola* No. 306. June, 1957. (Revised and reprinted March, 1960).

Yerkes, William D., Jr., J. S. Niederhauser, N. E. Borlaug, Eugenio Martínez S., and Jorge Galindo. Some plant diseases observed in Mexico in 1958. *Plant Disease Reporter* 43: 500-503. 1959.

Yerkes, William D., Jr., and C. Gardner Shaw. Taxonomy of the *Peronospora* species on Cruciferae and Chenopodiaceae. *Phytopathology* 49: 499-507. 1959.

Zaumeyer, W. J. and Graciano Patiño. Vein necrosis, another systemically infectious strain of alfalfa mosaic virus in bean. *Phytopathology* 50: 226-231. 1960.

Horticulture

Alvarez L., Eduardo, Ernesto H. Cásseres, and Guillermo Hernández B. Dos nuevas variedades de camote de alta calidad. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Andrade A., Enrique. Cómo producir su propia semilla de chile poblano. *Novedades Hortícolas* Vol. V, No. 1. January—March, 1960.

Castro, Macario, Guillermo Hernández, Jorge Medina, and Juventino Contreras. La distancia entre plantas afecta el tamaño y rendimiento de la cebolla. *Novedades Hortícolas* Vol. IV, No. 3. July—September, 1959.

García, Waldemar, Ernesto H. Cásseres, and William D. Yerkes. Combate de algunas de las enfermedades más frecuentes en las hortalizas. (Revised). *Novedades Hortícolas* Vol. IV, No. 2. April—June, 1959.

Gudiño M., Raymundo. Cultivo y variedades de cacahuate en el Estado de Veracruz. *Novedades Hortícolas* Vol. IV, No. 4. October—December, 1959.

Gudiño M., Raymundo. Horticultores progresistas. *Novedades Hortícolas* Vol. IV, No. 4. October—December, 1959.

Gudiño M., Raymundo and José Guevara C. Combate de los barrenadores del camote en el trópico. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Gudiño M., Raymundo, Guillermo Hernández, and Ernesto H. Cásseres. Cuitzeo y Catemaco, nuevas variedades de camote. *Boletín de Extensión Agrícola* No. 338. March, 1960.

Gudiño M., Raymundo and Josué Kohashi S. Se puede alargar el período de cosecha de tomate en Veracruz. *Novedades Hortícolas* Vol. IV, No. 3. July—September, 1959.

Guzmán M., Enrique. El cultivo de la alcachofa. *Novedades Hortícolas* Vol. V, No. 1. January—March, 1960.

Guzmán M., Enrique. El cultivo del espárrago. *Boletín de Extensión Agrícola* No. 316. May, 1958. (Revised and reprinted April, 1960).

Guzmán M., Enrique. Uso de herbicidas en los cultivos de zanahoria y chícharo en el Valle de Toluca, México. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Guzmán M., Enrique and Ernesto H. Cásseres. Principales plagas en las hortalizas y su combate. (Revised). *Novedades Hortícolas* Vol. V, No. 2, April—June, 1960, and Vol. V, No. 3. July—September, 1960.

Hernández Bravo, Guillermo and Ernesto H. Cásseres. Hortalizas de buena calidad representan mayores ingresos: IV. Lechuga y zanahoria. *Novedades Hortícolas* Vol. IV, No. 3. July—September, 1959.

Kohashi S., Josué. El petróleo es un buen herbicida económico para los primeros deshierbes de la zanahoria. *Novedades Hortícolas* Vol. V, No. 1. January—March, 1960.

Nieto, Víctor. Un grupo internacional de Horticultores visita la región citrícola de Río Verde, S. L. P. *Novedades Hortícolas* Vol. IV, No. 4. October—December, 1959.

Papers Presented

Cásseres, Ernest H., Ralph W. Richardson, Jr., and Martín Garatuza. The vegetable seed production area of Northwest Mexico. VII Annual Meeting, American Society for Horticultural Science (Caribbean Region). San José, Costa Rica. June, 1959.

Richardson, R. W., Jr., and E. H. Cásseres. Two new sweet potato varieties for Mexico. VII Annual Meeting, American Society for Horticultural Science (Caribbean Region). San José, Costa Rica. June, 1959.

FORAGE GRASSES AND LEGUMES

Alvarez Gómez, Angel. Boletín meteorológico del Estado de Chihuahua, 1958. *Circular La Campana* No. 2. September, 1959.

Buller, Roderic E., E. Hernández X., and Martín H. González. Grassland and livestock regions of Mexico. *Journal of Range Management* 13: 1-6. 1960.

Buller, Roderic E. and Pedro Sánchez de la Cruz. Tanverde: una nueva variedad de alfalfa para la Mesa Central. *Agricultura Técnica en México* No. 8. Summer, 1959.

González, Martín H. and Efraím Hernández X. Los Pastizales de Chihuahua: su división en zonas; los zacates nativos más importantes. *Circular La Campana* No. 3. November, 1959.

Hernández X., Efraím. Zacates indígenas. *Agricultura Técnica en México* No. 8. Summer, 1959.

Hernández X., Efraím. Zonas agrostológicas de Chihuahua. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Sánchez Durón, A. and Roderic E. Buller. Cómo obtener un buen alfalfa. *Boletín de Extensión Agrícola* No. 334. October, 1959.

Tapia J., Carlos and Candelario Carrera. Pangola, excelente zacate tropical para pastoreo. *Circular Cotaxtla* No. 2. November, 1958. (Revised and reprinted April, 1960).

Tapia J., Carlos, Candelario Carrera, and Roderic E. Buller. Zacate Alemán para terrenos inundables del trópico. *Circular Cotaxtla* No. 3. April, 1959. (Revised and reprinted April, 1960).

Tapia J., Carlos, Mario Ferrer, and Roderic E. Buller. Merkerón, zacate rendidor para tierra caliente. *Circular Cotaxtla* No. 1. May, 1958. (Revised and reprinted March, 1960).

Tapia J., Carlos, Héctor Muñoz C., and Roderic E. Buller. Jaragua, zacate para pastoreo en el trópico seco. *Circular Cotaxtla* No. 7. December, 1959.

Velasco, Marcial and Martín H. González. Combata la mosca del ganado con rascaderos. *Circular La Campana* No. 4. March, 1960.

SOILS

Arvizu R., Zeferino and R. J. Laird. Efecto de diferentes fuentes de nitrógeno sobre el rendimiento y contenido de proteína en el trigo. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Chávez R., Sabino and R. J. Laird. Calificación de algunos aspectos de las prácticas de riego usadas en las siembras de trigo en El Bajío y su relación con la respuesta a fertilizantes. *Folleto Técnico* No. 36. November, 1959.

Chávez R., Sabino and R. J. Laird. Intervalos de riegos para trigo en El Bajío. *Agricultura Técnica en México* No. 8. Summer, 1959.

Chena G., Rodolfo. Recuperación de un suelo sódico salino. *Agricultura Técnica en México* No. 8. Summer, 1959.

Laird, R. J., Roberto Núñez E., Fidencio Puente F., and Juan del Toro. Manejo de los

residuos de las cosechas en una rotación de maíz y trigo en El Bajío. *Folleto Técnico* No. 37. November, 1959.

Núñez E., Roberto and Reggie J. Laird. ¿Conviene asociar leguminosas con el trigo? *Agricultura Técnica en México* No. 8. Summer, 1959.

Ortega T., Enrique. Diagnóstico de las deficiencias de nitrógeno en el algodonero. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Ortega T., Enrique. Fertilización del algodonero en el Valle del Yaqui. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Sánchez D., Nicolás. Abono verde: fuente de nitrógeno. *Boletín de Extensión Agrícola* No. 318. 1958. (Reprinted December, 1959).

Sánchez D., Nicolás, Reggie J. Laird, Moisés Guillen, and Raúl Palacios Avilés. Fertilice su maíz y tendrá buenas ganancias. *Boletín de Extensión Agrícola* No. 323. 1959. (Revised and reprinted June, 1959).

Sánchez D., Nicolás and Mario Pérez. Respuesta del maíz a fertilizantes y a encalados en la Sierra de Michoacán. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

PLANT PATHOLOGY AND POTATO IMPROVEMENT

César López, Luis, Ramón Covarrubias, John S. Niederhauser, Roberto Núñez, and R. J. Laird. El carbón de la espiga del maíz. *Agricultura Técnica en México* No. 8. Summer, 1959.

Fernández B., Jesús and John S. Niederhauser. El cultivo de la papa en El Bajío. *Boletín de Extensión Agrícola* No. 332, October, 1959. (Revision of *Boletín de Extensión Agrícola* No. 295).

Martínez S., Eugenio. ¿Afecta al rendimiento la viruela del algodonero? *Agricultura Técnica en México* No. 8. Summer, 1959.

Niederhauser, John S., Jesús Fernández, Javier Cervantes, Gelasio Pérez, and Santiago Delgado. Tres nuevas variedades de papa resistentes al tizón tardío. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

ENTOMOLOGY

Barnes, Douglas, Ernesto de las Casas, and Marcos Ramírez Genel. Fumigación de granos almacenados. *Agricultura Técnica en México* No. 8. Summer, 1959.

Barnes, Douglas and Marcos Ramírez Genel Algunos conceptos sobre el almacenamiento de semilla de maíz. *Mejoramiento del Maíz—Proyecto Cooperativo Centroamericano: Quinta Reunión Centroamericana*. Panama. March, 1959. (Published in 1960).

Barnes, Douglas and Marcos Ramírez Genel. Combate de moscas en los gallineros. *Agricultura Técnica en México* No. 8. Summer, 1959.

Barnes, Douglas and William R. Young. Insecticidas, úselos correctamente y obtendrá buenos resultados. *Boletín de Extensión Agrícola* No. 333. October, 1959. (Revision of *Boletín de Extensión Agrícola* No. B 12. July, 1956).

Candia Z., Daniel and Douglas Barnes. El clima afecta el poder residual de los insecticidas. *Agricultura Técnica en México* No. 8. Summer, 1959.

Candia Z., Daniel and Douglas Barnes. Infestación del maíz en el campo por *Sitophilus oryza* (L.). *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Carrillo S., José Luis. Biología de *Macrodactylus mexicanus* Burm. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Gibson, William W. and José Luis Carrillo S. Lista de insectos en la colección entomológica de la Oficina de Estudios Especiales, S.A.G. *Folleto Misceláneo* No. 9. December, 1959.

Padilla A., Rafael and William R. Young. Insecticidas selectivos para el combate del pulgón manchado de la alfalfa. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Ramírez Genel, Marcos. Combata las moscas en sus gallineros. *Boletín de Extensión Agrícola* No. 324. July, 1959.

Sifuentes, Juan Antonio and William R. Young. El pulgón manchado de la alfalfa y su combate en el Valle del Yaqui. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Young, William R. and Juan Antonio Sifuentes. Biological and control studies on *Estigmene acrea* (Drury), a pest of corn in the Yaqui Valley, Sonora, Mexico. *Journal of Economic Entomology* 52: 1109-1111. December, 1959.

Papers Presented

Candia Z., Daniel and Douglas Barnes. Field infestations of *Sitophilus oryza* (L.) in native and hybrid corns in the Mexican tropics. Seventh

Annual Meeting, Entomological Society of America. Detroit, Michigan. December, 1959.

Candia Z., Daniel and Marcos Ramírez Genel. Recent studies on grain protectants in Mexico. Seventh Annual Meeting, Entomological Society of America. Detroit, Michigan. December, 1959.

Sifuentes, J. Antonio and William R. Young. Control of the corn leaf aphid, *Rhopalosiphum maidis* (Fitch) on barley in the Yaqui Valley, Sonora, Mexico. Southwestern Branch Meeting, Entomological Society of America. El Paso, Texas. February, 1960.

Young, William R. and Marcos Ramírez Genel. The influence of the soldier fly, *Hermetia illucens* (Linn.) on populations of house flies, *M. domestica* L. in manure under caged poultry. Seventh Annual Meeting, Entomological Society of America. Detroit, Michigan. December, 1959.

POULTRY

Pino, John A. El uso de maíz, sorgo y trigo en la alimentación de pollitos. *Agricultura Técnica en México* No. 8. Summer, 1959.

Pino, John A. ¿Es costeable su parvada? *Boletín de Extensión Agrícola* No. 335. December, 1959.

Pino, John A. Proteja sus aves del canibalismo. *Circular El Horno* No. 2. June, 1959.

Pino, John A., Luciano Crispín, and Manuel Cuca. ¿Dónde se comportan mejor las ponedoras? *Agricultura Técnica en México* No. 8. Summer, 1959.

Rojas S., Arturo. ¿Afectan los "nortes" a las gallinas en producción? *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

AGRICULTURAL ECONOMICS

Freebairn, Donald K. Costos e ingresos en la producción de huevo. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Freebairn, Donald K. and Guillermo Paredes Murillo. Producción y consumo de pollos y huevos en dos poblados rurales. *Agricultura Técnica en México* No. 8. Summer, 1959.

LIBRARY

Hill, Esther L. and Pablo Velásquez. Horticultura: lista de referencias preparado para el III curso internacional de horticultura sobre cultivos de consumo popular. México, D.F.: Oficina de Estudios Especiales, S.A.G., 1959.

MISCELLANEOUS

Borrego, Jaime. Cultivo del ajonjolí en el Noroeste. *Circular CIANO* No. 8. February, 1960.

Borrego, Jaime, Ramón G. Jasso, and Nicolás Sánchez D. Prueba de variedades de alfalfa para el Valle del Yaqui. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Borrego, Jaime and Nicolás Sánchez. Estudios con ajonjolí en el Noroeste. *Agricultura Técnica en México* No. 8. Summer, 1959.

Brauer H., Oscar. Androesterilidad provocada con Dalapón. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Guerrero S., Daniel. Qué se entiende por calidad de la semilla de trigo. *Agricultura Técnica en México* No. 8. Summer, 1959.

Jasso, Ramón G., Eugenio Martínez, and Nicolás Sánchez D. El azafrancillo, su cultivo en el Noroeste. *Circular CIANO* No. 7. October, 1959.

Nieto H., Jorge. Combata las malas hierbas con herbicidas. *Circular Cotaxtla* No. 6. December, 1959.

Nieto H., Jorge. Elimine las hierbas a tiempo. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Perry, J. P., Jr., and Augusto Donoso. Cuida tu tractor: consejos de mantenimiento. *Boletín de Extensión Agrícola* No. 314. January, 1958. (Revised and reprinted January, 1960).

Sánchez D., Nicolás, Ramón G. Jasso, Mariano Jiménez, Jaime Borrego, J. Antonio Sifuentes, Eugenio Martínez, and Samuel Ramos. Cómo producir más algodón por hectárea en el Valle del Yaqui. *Circular CIANO* No. 6. March, 1959. (Revised and reprinted, March, 1960).

Personal Técnico del CIANO. *EL CIANO y el Noroeste: 4 años de labor.* May, 1959.

Por los Centros de Investigación Agrícola. *Agricultura Técnica en México* No. 8. Summer, 1959.

Por los Centros de Investigación Agrícola. *Agricultura Técnica en México* No. 9. Winter, 1959-1960.

Information Section. Illustrated brochure for the 16 mm. colored sound film, "La Ciencia Agrícola Impulsa al Noroeste." April, 1960.

Information Section. Illustrated brochure for the 16 mm. colored sound film, "Manejo y utilización de la alfalfa." April, 1960.

COLOMBIAN AGRICULTURAL PROGRAM

Corn

Ramírez E., Ricardo, David H. Timothy, Efraín Díaz B., and U. J. Grant, in collaboration with G. Edward Nicholson Calle, Edgar Anderson, and William L. Brown. *Races of Maize in Bolivia.* Washington, D.C.: National Academy of Sciences—National Research Council, 1960.

Wheat, Barley, and Oats

Papers Presented

Gibler, John W. The enanismo disease in barley and sources of resistance. Fourth International Barley Research Workers Conference. Fargo, North Dakota. February, 1960.

Gibler, John W. and N. E. Borlaug. The composite cross and substitutions in disease and quality control. Fourth International Barley Research Workers Conference. Fargo, North Dakota. February, 1960.

Rice

Gálvez, Guillermo E. and Peter R. Jennings. Transmisión de la hoja blanca del arroz en Colombia. *Agricultura Tropical* XV, No. 8: 507-515. 1959.

Gálvez, Guillermo E., Peter R. Jennings, and H. David Thurston. Transmission studies of hoja blanca of rice in Colombia. *Plant Disease Reporter* 44: 80-81. 1960.

Gálvez, Guillermo E., H. David Thurston, and Peter R. Jennings. Transmission of hoja blanca of rice by the planthopper *Sogata cubana. Plant Disease Reporter* 44: 394. 1960.

Jennings, Peter R. Gulfrose, una nueva variedad de arroz resistente a la "hoja blanca." *Agricultura Tropical* XVI, No. 3: 167-170. 1960.

Pastures and Forages

Chaverra, H., L. V. Crowder, and S. Echeverri. Algunas consideraciones sobre la situación actual de la ganadería en Colombia. *Agricultura Tropical* XV, No. 4: 253-256. 1959.

Crowder, L. V., A. Michelin, B. Martínez, and G. B. Baird. La producción de alfalfa en Colombia: VII. Respuesta de la aplicación de bórax en el Valle del Cauca. *Agricultura Tropical* XV, No. 6: 387-395. 1959.

Crowder, L. V., O. L. Richardson, and A. McCormack. Producción de forraje de varias especies de gramíneas adaptadas a las condiciones del clima cálido de Colombia. *Agricultura Tropical* XVI, No. 2: 101-113. 1960.

Crowder, L. V., J. Vanegas, and A. Michelin. The adaptation and production of species and selections of grasses and clovers in Colombia. *Journal of Range Management* 12: 225-230. 1959.

Marín, G., L. V. Crowder, G. B. Baird, and R. Ramírez. Respuesta de la avena forrajera a nitrógeno y fósforo en dos tiempos de corte, en la Sabana de Bogotá. *Agricultura Tropical* XV, No. 5: 307-321. 1959.

Michelin, A. and L. V. Crowder. Influencia de los niveles y frecuencia de aplicación de nitrógeno en la producción de pasto pangola. *Agricultura Tropical* XV, No. 12: 843-852. 1959.

Soils

Gómez-S., Jairo A., Guy B. Baird, and Carlostadio Sánchez P. Respuesta del maíz a la aplicación de nitrógeno, fósforo y potasio en el Valle del Cauca (Colombia). *Agricultura Tropical* XVI, No. 1: 17-29. 1960.

Marín-Morales, Gildardo. La producción de alfalfa en Colombia: VIII. Encalamiento de los suelos de la Sabana de Bogotá, para cultivar alfalfa. *Agricultura Tropical* XVI, No. 3: 149-160. 1960.

Vega-J., Victor M., Guy B. Baird, and Manuel Rodríguez J. Algunos aspectos de la fertilización del trigo en suelos de la Sabana de Bogotá y alrededores. *Boletín Técnico* No. 4. 1959.

Wieczorek, Agathon and Guy B. Baird. Fertilización de la papa en Nariño. *Boletín de Divulgación* No. 7. 1959.

Plant Pathology

Guzmán-N., Julia, H. David Thurston, and Lee E. Heidrick. Naturaleza de la resistencia parcial de tres clones de papa al *P. infestans. Agricultura Tropical* XVI, No. 2: 89-99. 1960.

Aid to Research and Teaching

UNITED STATES

American Institute of Biological Sciences, Washington, D. C.: to enable two Latin American biologists to participate in the Biological Sciences Curriculum Study Conference held in Atlanta, Georgia, during January, 1960; $1,898.

Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York: study of obligate parasitism; $59,100.

Clemson Agricultural College, South Carolina: weather-recording equipment for the Department of Entomology and Zoology; $3,500.

Connecticut Agricultural Experiment Station, New Haven: research on the genetics of growth in plants; $6,400.

Conservation Foundation, New York:

Study programs on the use of chemical pesticides in urban areas; $30,000;

A preliminary conference concerning the use of chemical pesticides and their effect upon people and wildlife; $4,000.

Cornell University, Ithaca, New York:

Dr. Leon J. Tyler, professor of plant pathology, College of Agriculture; to visit centers of research in plant pathology in Europe; $4,640;

David B. Williams, director, Foreign Student Office; to visit educational institutions in Latin America; $3,000;

Dr. Damon Boynton, professor of pomology; to consult with horticulturists in Costa Rica and Mexico; $1,365;

Dr. Kenneth L. Turk, head, Department of Animal Husbandry, and member, The Rockefeller Foundation Board of Consultants for Agricultural Sciences; to participate in the XV International Dairy Congress in London, England; $1,300.

Entomological Society of America, Washington, D. C.: to invite an internationally recognized insect pathologist to participate in the Symposium on Biological Alternatives to Chemical Control; $1,340.

Fifth World Forestry Congress, Washington, D. C.: travel funds for participants in the Congress; $10,000.

Fund for the International Conference of Agricultural Economists, Inc., Chicago, Illinois: travel expenses of foreign scientists attending the XI International Conference of Agricultural Economists to be held in Mexico during August, 1961; $20,000.

Harvard University, Cambridge, Massachusetts: research and training of specialists in water resources and development; $106,000.

Iowa State University of Science and Technology, Ames:

Study of the biological and chemical bases of plant resistance to insect attack; $45,000;

Research on the nitrogen cycle in soil, in the Department of Agronomy; $21,200.

Kansas State University, Manhattan: study of the basic biochemical and physiological processes occurring in stored grain; $26,000.

Louisiana State University, Baton Rouge: support of a center for the training of agricultural scientists specializing in research on rice; $31,000.

Missouri Botanical Garden, St. Louis: laboratory equipment and supplies for research in plant physiology; $5,600.

National Academy of Sciences—National Research Council, Washington, D. C.:

Agricultural Board of the Division of Biology and Agriculture; to stimulate research and development programs in the agricultural sciences; $50,000;

Committee on Agricultural Pests of the Agricultural Board; study of agricultural losses caused by pests; $9,500.

Ohio Agricultural Experiment Station, Wooster: laboratory equipment and supplies and research expenses; $19,000.

Dr. Nicholas T. Mirov, physiologist, Pacific Southwest Forest and Range Experiment Station, Institute of Forest Genetics, and lecturer, University of California, Berkeley: to observe pine forests and work in herbaria in Southeast Asia; $4,400.

Polytechnic Institute of Brooklyn, New York: study of ion-selective membrane evaluation; $7,500.

Purdue University, Lafayette, Indiana:

Study of senescence in plants, under the direction of Dr. A. C. Leopold; $18,000;

A symposium on the growth process in living matter, held during the summer, 1960; $10,000;

Dr. C. L. Dhawan, Department of Agronomy; to accept a post with the cooperative sorghum improvement research program in New Delhi, India, supported jointly by the Ministry of Food and Agriculture of India and The Rockefeller Foundation; $1,325.

Research Foundation of the State University of New York, Albany: State University College of Forestry, Syracuse University; research on the white pine blister rust pathogen; $5,000.

Texas Agricultural and Mechanical College System, College Station: support of a training program for foreign students specializing in rice improvement and management; $28,500.

Texas Research Foundation, Renner: evaluation of the ancient agriculture of the lowland Mayan area of Guatemala, by Dr. C. L. Lundell; $9,600.

United States Department of Agriculture:

Dr. Etlar L. Nielsen, research agronomist, Agricultural Research Service, Madison, Wisconsin; to visit centers of research in plant genetics in Europe; $2,460;

Dr. Foster E. Mohrhardt, director, United States Department of Agriculture Library, Washington, D. C.; to attend a seminar on agricultural documentation being held in Germany at the invitation of the Organization for European Economic Cooperation, and to confer with agricultural librarians in Europe; $1,430.

University of Arizona, Tucson: a program of inter-university cooperation with the University of Sonora, Hermosillo, Mexico; $10,000.

University of California, College of Agriculture, Davis:

Dr. William B. Hewitt, professor of plant pathology; to visit centers of research in plant pathology in Europe; $2,937;

Dr. Dewey J. Raski, associate nematologist; to confer with plant pathologists in the United States and Europe; $1,405.

University of Hawaii, College of Agriculture, Honolulu:

Scholarships for students from Asian and Pacific Basin countries; $100,000;

Dr. Morton M. Rosenberg, dean; to visit agricultural colleges in Asia; $4,200.

University of Illinois, Urbana:

Research on the biochemistry of insects; $45,000;

Dr. R. H. Hageman, associate professor of plant physiology, Department of Agronomy, College of Agriculture; to conduct research in England during a sabbatical leave; $5,000;

Michael Piechowski, assistant, Institute of Plant Breeding, Poznan, Poland; to study for the doctoral degree at the University of Illinois; $1,000.

University of Minnesota, Minneapolis:

Research on genetic potentialities in wheat and its principal pathogens; $20,000;

Genetic studies of Ethiopian hard wheats, at the Institute of Agriculture, St. Paul; $10,000.

Dr. John H. Lonnquist, professor of agronomy, College of Agriculture, University of Nebraska, Lincoln: to visit the Institute of Genetics, Luiz de Queiroz College of Agriculture, Piracicaba, Brazil; $1,300.

University of Wisconsin, Madison:

Study of the utilization of solar energy devices in underdeveloped areas; $45,000;

Expenses of foreign scientists attending the VII International Soil Science Congress; $25,000;

Study of the residues of fungicides on crop plants, under the direction of Dr. J. E. Mitchell, College of Agriculture; $10,000;

Dr. K. P. Buchholtz, professor of agronomy, College of Agriculture; to visit centers of botanical and agricultural research in Europe; $1,705.

Washington State University, Pullman: development of equipment for use in field crop experiments, by the Department of Agronomy; $1,000.

WEST INDIES

TRINIDAD

Norman W. Simmonds, senior cytogeneticist, Regional Research Centre, Imperial College of Tropical Agriculture, St. Augustine: to visit The Rockefeller Foundation Mexican Agricultural Program; $700.

LATIN AMERICA

ARGENTINA

National University of Cuyo, Mendoza: chemicals and equipment for the Faculty of Agrarian Sciences; $8,000.

BRAZIL

Ministry of Agriculture, National Service of Agronomic Research, Rio de Janeiro: research on animal diseases caused by toxic plants and mineral deficiencies, at the Institute of Animal Biology; $6,000.

Dr. Antonio Vieira Machado, director, School of Veterinary Medicine, Rural University of the State of Minas Gerais, Belo Horizonte: to visit schools of veterinary medicine in Canada, the United States, and Latin America; $2,900.

São Paulo State Secretariat of Agriculture, São Paulo:

Equipment for research in plant science at the Institute of Agronomy, Campinas; $68,000;

Books and journals for the library of the Institute of Biology; $10,000.

University of Ceará, Fortaleza: an ultracentrifuge for the School of Agronomy; $10,000.

University of Rio Grande do Sul, Pôrto Alegre:

Development of the teaching and research programs of the School of Agronomy and Veterinary Medicine; $94,400;

Dr. Jose Grossman, head, Institute of Forage Crops Studies, School of Agronomy and Veterinary Medicine; to visit scientific research centers and to participate in scientific meetings in Europe; $3,900;

Professor Outubrino Corrêa, director, School of Agronomy and Veterinary Medicine; to visit centers of veterinary research in the United States; $2,945.

CHILE

Catholic University of Chile, Santiago: development of the Faculty of Agronomy; $100,000.

Ministry of Agriculture, Santiago:

Equipment for the Laboratory of Soil Research; $10,000;

Equipment and accessories for the Nutrition Laboratory, Institute of Veterinary Investigations; $10,000.

COLOMBIA

Ministry of Agriculture, Bogotá:

Development of two regional diagnostic laboratories for animal diseases; $50,000;

Dr. Gustavos Riveros, head, Laboratory of Artificial Insemination, Department of Agricultural Research; to visit agricultural centers conducting artificial insemination programs in the United States; $2,500;

Dr. Bernardino Rodriguez U., Animal Science Section, Department of Agricultural Research; to visit agricultural centers conducting artificial insemination programs in the United States; $2,500;

Dr. Canuto Cardona, director, Department of Agricultural Research; to visit leading agricultural colleges and experiment stations in the United States; $1,575;

Ing. Agr. Enrique Llano, director, Palmira Experiment Station; to visit leading agricultural colleges and experiment stations in the United States; $1,575.

National University of Colombia, Bogotá: development of a diagnostic and research laboratory for animal diseases in the Faculty of Veterinary Medicine; $150,000.

University of the Andes, Bogotá: research on the deterioration of stored grain by fungi; $5,000.

Ing. Agr. Humberto Gutiérrez, dean, School of Agronomy, University of Caldas, Manizales: to visit leading agricultural colleges and experiment stations in the United States; $1,575.

COSTA RICA

Inter-American Institute of Agricultural Sciences, Turrialba:

Cooperative research in horticulture by the institute and The Rockefeller Foundation Mexican Agricultural Program; $13,360;

Revision, adaptation, and translation of his textbook, *Elements of Farm Management*, by Dr. John A. Hopkins; $3,525.

MEXICO

Ing. Quirino Orta, Coahuila State General Agricultural Division, Saltillo: to attend a course in photogrammetry in Munich, Germany; $1,595.

Ing. Jesús Fernandez Barrera, extension specialist, General Agricultural Division, Ministry of Agriculture, Mexico City: to visit centers of potato production in the United States and research centers in Canada, and to attend the IX International Botanical Congress in Montreal; $2,280.

Ing. Emilio Gutiérrez Roldán, director, National Corn Commission, Mexico City: to visit corn research and production centers in Latin America; $2,400.

National School of Agriculture, Chapingo:

Development of a Graduate School of Agriculture; $100,000;

Miss Evangelina Villegas, cereal chemist; to visit milling and baking laboratories in the United States and Canada; $1,900;

Ing. Mario E. Ríos González, botanist; to visit the Missouri Botanical Garden, St. Louis; $740;

Ing. Jesús Múñoz Vásquez, director; to visit the University of California at Davis; $550.

Technological Institute and School of Advanced Studies of Monterrey: development of the teaching and research programs of the School of Agriculture; $112,000.

Ing. Hugo Alejo Velasco, professor and head, Department of Soils, Antonio Narro College of Agriculture, University of Coahuila, Saltillo: to visit the United States Salinity Laboratory, Riverside, California; $4,250.

PERU

Agrarian University, La Molina, Lima: development of the postgraduate teaching and research program; $300,000.

Ministry of Agriculture, Lima: development of research centers and of crop research projects, by the Cooperative Program of Agricultural and Livestock Experimentation; $75,000.

University of San Marcos, School of Veterinary Medicine, Lima:

To invite Dr. Donald D. Delahanty, professor of surgery, New York State Veterinary College, Cornell University, Ithaca, New York, to assist in the organization and development of the new clinic for large animals; $9,975;

Dr. Carlos E. Chavez, professor and head of parasitological research; to review experimental techniques for determining the effect of parasites and parasitic diseases on ruminants at laboratories in the United States; $2,975.

EUROPE

ITALY

Catholic University of the Sacred Heart, Milan: laboratory equipment and field and research expenses for the Plant Genetics Institute, Piacenza; 2,560,606 Italian lire (about $4,225).

NETHERLANDS

Albertus Rozendaal, scientific officer, Agricultural University, Wageningen: to visit centers of research in plant pathology in the United States; $1,440.

POLAND

Central Agricultural Library, Warsaw: books and equipment; $10,000.

College of Agriculture, Cracow:

Equipment for research in the plant and animal sciences; $35,000;

Dr. Wladyslaw Bielanski, chair of animal hygiene; to visit animal breeding centers in the United States and Europe; $3,225;

Dr. Adam Markowski, professor of plant physiology; to visit plant physiology centers in the United States and Europe; $3,150.

College of Agriculture, Olsztyn:

Kazimierz Odo Rouppert, Department of Meadows and Pastures; to visit soil science centers in Europe; $2,400;

Dr. Zygmunt Tomaszewski, Department of Plant Breeding; to visit plant breeding centers in Sweden, Denmark, and West Germany; $1,800.

College of Agriculture, Poznan:

Equipment for the Institute of Biochemistry and the Department of Plant Physiology; $20,000;

Dr. Karol Manka, chair of forest pathology; to visit plant pathology centers in Europe, Canada, and the United States; $3,525.

Dr. Stefan Guminski, Department of Plant Physiology, College of Agriculture, Wroclaw: to visit plant physiology centers in Europe; $1,950.

Dr. Mieczyslaw Antoni Janicki, head, Animal Products Laboratory, Institute of Animal Physiology and Nutrition, Bydgoszcz: to visit nutrition centers in Europe, Canada, and the United States; $3,700.

Dr. Zygmunt Soczek, head, Orchard Cultivation Department, Institute of Pomology, Skierniewice: to visit horticultural research centers while in the United States; $750.

Dr. Jadwiga Ziemiecka, head, Department of Agricultural Microbiology, Institute of Soil Management and Plant Cultivation, Pulawy: to attend the VII International Soil Science Congress in Madison, Wisconsin, and to visit centers of research in soil science in the United States; $2,800.

Institute of the Technology of Animal Products, Gdansk-Wrzeszcz: research equipment; $5,750.

Polish Academy of Sciences, Warsaw:

To invite two animal scientists from the United States to participate in a seminar on animal breeding held in Poland during 1960; $4,075;

Dr. Henryk Sandner, Institute of Ecology; to visit nematology centers in Europe; $1,675.

Veterinary Institute of Pulawy: equipment for research on animal viruses; $30,000.

SPAIN

National Institute of Agricultural Investigations, Madrid: research on corn breeding, at the Center for Corn Improvement; $10,000.

SWEDEN

Dr. Axel Nygren, Institute of Genetics, Uppsala: to consult with scientists in the United States and Canada; $1,750.

Dr. Daniel Lihnell, head, Department of Botany, Swedish State Plant Protection Institute, Solna: to consult with plant pathologists in the United States, Canada, and Mexico; $2,650.

UNITED KINGDOM

Dr. J. E. Crosse, bacteriologist, East Malling Research Station, Maidstone: to visit centers of research in plant pathology in the United States and Canada; $2,920.

John Innes Horticultural Institution, Bayfordbury:

Dr. Kenneth S. Dodds, director; to study indigenous cultivated potatoes in South America; $3,130;

Dr. Graham J. Paxman, plant scientist; to study indigenous cultivated potatoes in South America; $3,130.

National Vegetable Research Station, Wellesbourne: an ultracentrifuge for research in plant pathology; $6,900.

Rowett Research Institute, Bucksburn:

Equipment for research in animal physiology and nutrition; $20,200;

Research in animal physiology and nutrition; $14,750.

Scottish Horticultural Research Institute, Invergowrie:

Equipment for research in plant pathology; $10,000;

R. M. Lister, plant scientist; to confer with plant scientists in the United States; $2,500.

Dr. E. A. FitzPatrick, lecturer, Department of Soil Science, University of Aberdeen: to confer with soil scientists in the United States; $2,690.

University of London:

Equipment for the Department of Biological Sciences, Wye College; $7,200;

Professor Dunstan Skilbeck, Wye College; to visit agricultural research and education centers while in the United States; $900.

Sir John Cockcroft, member for scientific research, United Kingdom Atomic Energy Authority, Harwell: to attend the Federal Science Congress in Salisbury, Southern Rhodesia; $1,600.

AFRICA

CONGO

Lovanium University, Leopoldville: equipment for the Institute of Agriculture; $26,300.

ETHIOPIA

Imperial Ethiopian College of Agricultural and Mechanical Arts, Dire Dawa: library development; $40,000.

Jimma Agricultural Technical School; library development; $10,000.

KENYA

East Africa High Commission, Nairobi:

Research on the environmental physiology of cattle, at the East African Veterinary Research Organization, Muguga; $20,000;

Spectrographic equipment for research in plant science and soil science, at the East African Agriculture and Forestry Research Organization, Kikuyu; $9,000;

Equipment for research in nematology and microbiology, at the East African Agriculture and Forestry Research Organization, Kikuyu; £3,000 (about $8,600);

Equipment for the Sorghum Breeding Research Unit, Serere, Uganda, of the East African Agriculture and Forestry Research Organization, Kikuyu; $4,270.

J. F. Griffiths, officer in charge, Research Section, East African Meteorological Department, Nairobi: to visit meteorological and climatological laboratories in the United States; $5,000.

East African Veterinary Research Organization, Muguga:

Walter Plowright, senior veterinary pathologist; to visit centers of veterinary research in the United States and Canada; $3,960;

Dr. H. R. Binns, director, and Mrs. Binns; to visit veterinary research and education centers while in the United States; $1,900;

Miss Jane B. Walker, research officer and entomologist; to confer with entomologists in the United States and Canada; $1,900.

Ministry of Agriculture, Animal Husbandry, and Water Resources, Nairobi:

Development of the Siriba Training College for African students; $171,000;

Books and periodicals for the regional agricultural research stations of the Department of Agriculture; $10,000;

H. C. Thorpe, senior plant breeder, Department of Agriculture, Njoro; to observe wheat improvement research programs in Latin America; $6,220;

Michael N. Harrison, plant breeder, Department of Agriculture, Kitale; to visit the Mexican and Colombian Agricultural Programs of The Rockefeller Foundation while in the Americas; $825;

Dr. R. G. Poultney, Grassland Research Station, Kitale; to visit The Rockefeller Foundation Colombian Agricultural Program and to observe experimental techniques used in plant nutrient and soil fertility studies while in the United States; $735.

NIGERIA

University College, Faculty of Agriculture, Ibadan:

Research in plant and animal science and in production economics; $40,000;

Professor G. E. Udom, farm manager; to observe farm practices in the United States; $4,750.

RHODESIA AND NYASALAND

Domboshawa Government School, Causeway: library development; $2,500.

D. E. Baker, senior young farmers' club organizer, Federal Department of Conservation and Extension, Salisbury: to observe youth clubs, extension methods, and farm practices in the United States; $6,180.

SUDAN

University of Khartoum: development of the teaching and research programs of the Faculties of Agriculture and of Veterinary Science; $41,300.

TANGANYIKA

Ministry of Finance and Economics, Dar es Salaam: development of the research station libraries of the Department of Agriculture; $10,000.

A. K. Auckland, plant breeder, Department of Agriculture, Ministry of Natural Resources, Dar es Salaam: to visit centers of research on sesame and soya breeding in the United States; $3,180.

Treasury of the Tanganyika Government, Dar es Salaam: expenses of rural surveys to be conducted by the Statistical Department, Economic Division; $10,000.

UGANDA

Peter H. LeMare, soil chemist, Cotton Research Station, Namulonge: to confer with soil scientists in the United States and Canada; $900.

Dr. Hugh Doggett, sorghum breeder, East African Agriculture and Forestry Research Organization, Soroti: to visit centers of sorghum research in the United States and Mexico; $4,400.

Makerere College, Kampala: to invite William Banage, graduate student, University of Durham, England, to serve as junior research fellow—demonstrator in the Faculty of Agriculture; $10,000.

UNION OF SOUTH AFRICA

Dr. A. Joffe, plant physiologist, Plant Physiological Research Institute, University of Pretoria: to attend the IX International Botanical Congress in Montreal, Canada, and to visit centers of plant physiology research in Europe, Canada, and the United States; $3,500.

MIDDLE EAST

ISRAEL

Agricultural Research Station, Rehovot: research on soil-water-plant relations; $70,000.

Hebrew University of Jerusalem: research on ancient agricultural systems in the Negev; $110,000.

LEBANON

American University of Beirut: graduate studies in the United States in the field of irrigation, by Professor Salim Macksoud, associate professor of agriculture, School of Agriculture; $5,000.

SOUTH ASIA

CEYLON

Dr. F. N. Ponnamperuma, head, Division of Chemistry, Department of Agriculture, Peradeniya: to participate in the VII International Soil Science Congress in Madison, Wisconsin, and to visit research centers in the United States, England, and South Asia; $1,500.

INDIA

Dr. Mohhamad Qadiruddin Khan, joint director of agriculture for Andhra Pradesh, Hyderabad: to visit centers of agricultural education, research, and extension in Japan, the Philippines, and the United States; $5,400.

Dr. Kapil Deo Singh, librarian, Balwant Rajput College, Agra: to visit centers of library science in the United States; $5,310.

Bihar Department of Agriculture:

> S. D. Sinha, soil survey officer, Sabour, Bhagalpur; to study at Cornell University, Ithaca, New York, and to observe soil survey programs at institutions in the United States; $6,270;
>
> Dr. Amalendu Ganguly, pathologist, Sugarcane Research Institute, Pusa; to review plant virus

disease research at centers in Europe, the United States, and the Far East, and to attend the IX International Botanical Congress in Montreal, Canada; $5,300.

Coimbatore Agricultural College and Research Institute: laboratory and field research equipment; $135,000.

Indian Council of Agricultural Research, New Delhi:

To purchase abroad offshoots of date palms adapted to Indian climatic and soil conditions; $6,000;

Dr. Narendra Lal Dhawan, associate coordinator, Maize Improvement Scheme; to study maize breeding and improvement programs in Mexico, Colombia, and the United States, and to attend meetings of the American Society of Agronomy; $4,000.

Indian Society of Genetics and Plant Breeding, New Delhi: to publish the proceedings of a special Symposium on Genetics and Plant Breeding in South Asia held in New Delhi during January, 1957; $3,000.

Ministry of Food and Agriculture, New Delhi:

L. Venkataratnam, horticultural specialist, Extension Wing, Department of Agriculture; to visit centers of horticultural research in Asia, the Middle East, Europe, and the United States; $5,800;

Dr. J. K. Basu, senior soil conservation director; to participate in the United Nations Food and Agriculture Organization Watershed Management Seminar and group study tour in the United States; $3,300.

West Bengal Ministry of Agriculture, Calcutta:

Scientific equipment, supplies, and library materials for the West Bengal State College of Agriculture and Agricultural Research Institute, Haringhata; $65,000;

Dr. H. K. Nandi, director of agriculture, and Mrs. Nandi; to visit centers of agricultural education and research in Southeast Asia, the United States, and Europe; $7,450;

N. C. Ray, joint director of agricultural marketing; to study agricultural marketing problems at universities and research institutions in the United States, Europe, and Asia; $5,200.

INDONESIA

Central Institute for Natural Research, Bogor: library materials for the Central Library of Science; $10,000.

University of Indonesia, Bogor:

Equipment and library materials for the teaching and research program of the Faculty of Veterinary Science; $42,000;

Dr. Bachtiar Rifai, professor of farm management, Faculty of Agriculture; to visit farm management centers in the Philippines, Japan, the United States, and Italy; $6,600;

Dr. A. J. Darman, Faculty of Veterinary Science; to consult with scientists in the United States and Argentina; $5,150;

Dr. Moh Mansjoer, professor of veterinary science, Faculty of Veterinary Science; to visit universities and research institutes in the United States; $4,500;

Dr. Didi Atmadilaga, lecturer in animal husbandry, Faculty of Veterinary Science; to visit animal husbandry centers in the United States, Mexico, the Philippines, and Japan; $4,300.

THAILAND

Kasetsart University, Bangkok:

Laboratory equipment and supplies for the College of Veterinary Science; $50,000;

Nai Jinda Thiemmedh, vice-dean, College of Fisheries; to visit centers of fish biology and culture in Japan, the United States, and Great Britain; $6,000.

Chi Wen Chang, United Nations Food and Agriculture Organization agricultural advisor in Thailand, Bangkok: to observe agricultural extension programs at land-grant institutions in the United States and agricultural institutions in England and the Netherlands; $4,025.

VIET NAM

Ministry of Agriculture, Saigon: equipment, supplies, and books for the Laboratory of Soil Science; $3,600.

FAR EAST

AUSTRALIA

Commonwealth Scientific and Industrial Research Organization:

Scientific equipment for the Divisions of Plant Industry and Entomology, Canberra; $100,000;

Scientific equipment for the Division of Tropical Pastures, Brisbane; $30,000.

William B. McGlasson, research horticulturist, Department of Agriculture, Adelaide: to accept an appointment as research assistant at the University of California, Davis; $1,600.

University of Adelaide:

To construct and equip an insectary; $10,000;

Dr. D. C. Swan, head, Department of Entomology, Waite Agricultural Research Institute; to visit centers of research in entomology in the United States and Canada; $3,160;

W. G. Allden, Department of Agronomy, Waite Agricultural Research Institute; to observe methods and techniques of research on the growth and nutrition of ruminants at centers in the United States; $2,700;

Dr. Rupert J. Best, reader in virology; to consult with biochemists and plant pathologists in Canada and the United States; $2,550.

Dr. Gordon L. McClymont, professor of rural science, Faculty of Rural Science, University of New England, Armidale: to visit agricultural research centers while in the United States attending the Fifth International Congress on Nutrition; $1,250.

Glenorchy McBride, lecturer in animal genetics, University of Queensland, Brisbane: to visit universities and research institutes in the United States; $2,000.

JAPAN

Hokkaido National Agricultural Experiment Station, Sapporo:

Scientific periodicals for the library; $10,000;

Takaichi Nishikata, head, Department of Agricultural Chemistry; to visit agricultural colleges and experiment stations in the United States and Europe; $3,800.

Hokkaido University, Sapporo:

Scientific equipment for the research program of the Faculty of Agriculture; $18,000;

Dr. Daiki Murayama, professor of plant pathology; to visit laboratories of plant pathology in Europe, Canada, and the United States; $4,150.

Japan Women's University, Tokyo: development of a graduate school of home economics; $48,000.

Kanazawa University: equipment and supplies for research on photosynthesis in the rice plant, by Dr. Kojiro Nishida; $10,000.

Iwao Nikki, Kanto-Tosan National Agricultural Experiment Station, Konosu: to visit forage crop and grassland management research centers in the United States and Europe; $5,050.

Kyushu National Agricultural Experiment Station, Chikugo: scientific equipment for use in the agricultural research program; $15,000.

Dr. Hisayoshi Iwata, professor of animal nutrition, Kyushu University, Fukuoka: to visit centers of research in animal nutrition in Europe and the United States; $4,175.

Ministry of Agriculture and Forestry, Tokyo: research on the use of upland soils; $130,000.

Heihachiro Miyayama, Science Research Aid Section, Ministry of Education, Tokyo: to visit science organizations and universities in the United States; $3,200.

Nagoya National University: books for the library of the Faculty of Agriculture; $10,000.

National Institute of Agricultural Sciences, Tokyo:

Toyokazu Yamada, head, Forage Crop Division, Chiba; to visit forage crop research centers in the United States and Europe; $5,400;

Dr. Yoshiaki Mihara, head, Division of Meteorology; to visit meteorological research centers in the United States; $3,950;

Dr. Koichi Sato, head, Pomology Section, Hiratsuka; to visit research centers in the United States and Canada; $3,850;

Takeshi Hayashi, head, Department of Plant Physiology and Genetics; to consult with plant scientists in the United States, Canada, and Europe; $2,710;

Masatada Oyama, chief, Division of Soil Survey; supplement to an earlier grant in aid for additional expenses of visits to agricultural research centers in the United States; $300.

Dr. Osamu Itikawa, head, Third Research Division, National Institute of Animal Health, Tokyo: to visit centers of veterinary research in Europe and the United States; $4,500.

Dr. Shoichi Tanaka, director, Horticultural Station, National Tokai-Kinki Agricultural Experiment Station, Shizuoka: to visit citrus centers in the United States and Europe; $1,500.

Obihiro Zootechnical University: research on forage crop management and animal nutrition; $19,000.

Dr. Jun Kobayashi, professor, Ohara Institute for Agricultural Biology, Okayama University: to visit agricultural education and research centers in the United States; $4,050.

Tohoku University, Sendai:

Dr. Motoyoshi Umezu, professor of animal physiology; to visit laboratories of animal physiology in the United States and Europe; $4,850;

Dr. Masayoshi A. Hatanaka, associate professor of fisheries biology, Faculty of Agriculture; to visit scientific institutions in the United States and Canada; $3,025.

Dr. Hiroshi Tamiya, director, Tokugawa Institute for Biological Research, Tokyo: to visit research centers in the United States and Europe; $2,330.

University of Tokyo:

Dr. Saburo Tamura, assistant professor, Department of Agricultural Chemistry; to visit biochemistry centers in the United States; $4,000;

Professor Itizo Mine, Department of Forestry; to visit forestry management centers in the United States; $3,925;

Professor Shutaro Yamamoto, head, Department of Veterinary Pathology; to visit centers of veterinary education and research in the United States; $3,900.

KOREA

Seoul National University: research in forest-tree breeding and propagation at the College of Agriculture, Suwon; $7,600.

NATIONAL REPUBLIC OF CHINA

National Taiwan University, Taipei: equipment and supplies for research and teaching in the College of Agriculture; $40,000.

Taiwan Agricultural Research Institute, Taipei: development of the rice research program; $45,000.

NEW ZEALAND

Department of Scientific and Industrial Research, Palmerston North:

An analytical ultracentrifuge for the research program of the Plant Diseases Division, Auckland; $10,000;

Dr. A. T. Johns, director; to visit plant biochemistry laboratories while in the United States; $775.

PHILIPPINES

Professor Victoriano A. Gaborno, Central Luzon Agricultural College, Nueva Ecija: to consult with scientists in the United States; $3,600.

Mindanao Agricultural College, Musuan:

Laboratory equipment and supplies; $50,000;

Professor Andres T. Lucas; to visit rice research centers in Asia; $3,125.

University of the Philippines, Quezon City:

Equipment and supplies for the College of Agriculture, Los Baños; $230,000;

Construction and equipment of a new classroom and laboratory building for the Department of Home Economics; $150,000;

Scholarships in the College of Agriculture, Los Baños, for students from Southeast Asian countries; $100,000;

To establish a rotating fund for the publication of the researches of the College of Agriculture, Los Baños; $5,000;

Cledualdo B. Perez, Jr., assistant instructor, Department of Animal Husbandry, College of Agriculture, Los Baños; to undertake graduate study and research in animal nutrition in the United States; $1,800.

Fellowship, Scholarship, and Training Awards

Active from January 1, 1959, to June 30, 1960

ROCKEFELLER FOUNDATION OPERATING UNITS AWARDS

Awarded from the Chilean Agricultural Program

NAME	FIELD	PLACE OF STUDY
Caglevic Dragicevic, Milan	Plant Science—Pathology	University of Wisconsin
Campos Street, Luciano	Plant Science—Economic Entomology	University of California, Davis
Cortázar Sagarminaga, René	Plant Science—Genetics—Plant Breeding	University of Minnesota
Grove Valenzuela, Hiram	Plant Science—Agronomy	Purdue University
Silva Fuentes, Jorge	Plant Science—Agronomy	University of Kentucky
Valdes Fabres, Alberto	Soil Science	University of California, Davis
Vicens Obrador, José Jaime	Plant Science—Agronomy	University of Adelaide, Australia

Awarded from the Colombian Agricultural Program

NAME	FIELD	PLACE OF STUDY
Alvárez Rico, José Manuel de Bernardo	Animal Science—Physiology	Purdue University
Barros Nieves, Ovidio	Plant Science—Pathology	Purdue University
Bastidas R., Alfonso	Plant Science—Agronomy	University of Georgia
Camacho, Luis H.	Plant Science—Genetics—Plant Breeding	North Carolina State College
Díaz Botero, Efraín	Plant Science—Genetics—Plant Breeding	University of Florida
Díaz Rodríguez, Genaro	Soil Science	University of Georgia
Duarte, Rodrigo	Plant Science—Genetics—Plant Breeding	Michigan State University
Echeverri E., Silvio	Plant Science—Agronomy	Oregon State College
García, Luis Alberto	Plant Science—Genetics—Plant Breeding	University of Minnesota
Gartner Nicholls, Alvaro	Plant Science—Genetics—Plant Breeding	Purdue University

NAME	FIELD	PLACE OF STUDY
Gómez L., Jairo Antonio	Soil Science	Iowa State University
Holguín Mosquera, Jorge Enrique	Plant Science—Agronomy	Pioneer Hi-Bred Corn Company, Johnston, Iowa
Lotero C., Jaime	Plant Science—Agronomy	University of Florida
Posada Ochoa, Lazaro	Plant Science—Economic Entomology	Kansas State College
Revelo Pepinosa, Miguel Antonio	Plant Science—Entomology	Iowa State University
Rosero Morán, Manuel Jesús	Plant Science—Genetics—Plant Breeding	University of Minnesota
Saldarriaga Vélez, Alfredo	Plant Science—Economic Entomology	North Carolina State College
Sierra, José Antonio	Plant Science—Genetics	University of Wisconsin
Torregroza Castro, Manuel	Plant Science—Genetics	University of Nebraska
Van Cotthem M., Luis Carlos	Animal Science—Physiology	Oklahoma State University

Awarded for Study at the Colombian Agricultural Program

NAME	FIELD	COUNTRY
Acauan, Benedicto Rosat	Plant Science—Agronomy	Brazil
Fuentes Castañon, Adolfo	Plant Science—Genetics—Plant Breeding	Guatemala

Awarded from the Mexican Agricultural Program

NAME	FIELD	PLACE OF STUDY
Acosta Carreón, Aristeo	Plant Science—Genetics—Plant Breeding	University of Missouri
Aguilar Yépez, Samuel	Soil Science	University of California, Davis
Aguilera Amezcua, Augusto	Animal Science	University of Illinois
Agundis Mata, Omar	Plant Science—Agronomy	Ohio State University
Alvárez y Luna, Eduardo	Plant Science—Genetics—Plant Breeding	Cornell University
Angeles Arrieta, Hermilo Hugo	Plant Science—Genetics—Plant Breeding	University of Nebraska
Barriga Solorio, Celio	Plant Science—Genetics	Michigan State University
Brauer Herrera, Oscar	Plant Science—Genetics—Plant Breeding	University of Göttingen, Germany
Cárdenas Ramos, Francisco	Plant Science—Genetics—Plant Breeding	Michigan State University
Casas Díaz, Eduardo	Plant Science—Genetics—Plant Breeding	North Carolina State College
Cervantes Romo, Javier	Plant Science—Genetics—Plant Breeding	University of Wisconsin
Chan, Ricardo Moreno	Animal Science—Poultry	Michigan State University
Chávez Ruiz, Sabino	Soil Science	Oklahoma State University
Crispín Medina, Alfonso	Plant Science—Pathology	University of California, Davis
Cuca García, Manuel	Animal Science—Poultry	Washington State University
Dávila Guzmán, Edmundo	Plant Science—Pathology	University of Minnesota
de las Casas Aguirre, Ernesto	Plant Science—Entomology	University of Minnesota

NAME	FIELD	PLACE OF STUDY
Delgado Sánchez, Santiago	Plant Science—Pathology	University of California, Davis
Espino Tejeda, Silvestre	Plant Science—Genetics—Plant Breeding	North Dakota Agricultural College
Ferrer Fernández, Mario	Plant Science—Agronomy	Louisiana State University
Flores Reyes, Isaias P.	Plant Science—Horticulture	University of California, Davis
Gaona Rodríguez, Homero	Plant Science—Pathology	Cornell University
Garza Falcón, Eduardo R.	Plant Science—Genetics—Plant Breeding	Colorado State University
Garza Montemayor, Antonio	Plant Science—Genetics—Plant Breeding	University of Georgia
Garza Treviño, Ricardo	Plant Science—Agronomy	University of California, Davis
Gil Flores, Javier	Plant Science—Agronomy	Purdue University
Guerrero Sandoval, Daniel	Plant Science—Physiology	Iowa State University
Hernández Bravo, Guillermo	Plant Science—Horticulture	Pennsylvania State University
Kohashi Shibata, Josué	Plant Science—Genetics	Cornell University
Martínez Salazar, Eugenio	Plant Science—Plant Pathology	University of Wisconsin
Muñoz Garza, Juan Manuel	Plant Science—Genetics—Plant Breeding	University of Nebraska
Navarro Franco, Manuel	Plant Science—Agronomy—Plant Pathology	University of Wisconsin
Núñez Escobar, Roberto	Soil Science	University of California, Davis
Ortega Castro, Jacobo	Plant Science—Pathology	University of Minnesota
Ortega Corona, Alejandro	Plant Science—Economic Entomology	Ohio State University
Pacheco Mendívil, Francisco	Plant Science—Economic Entomology	University of Illinois
Padilla Aranda, Rafael	Plant Science—Economic Entomology	University of Massachusetts
Puente Flores, Fidencio	Soil Science	Oklahoma State University
Reyes Castañeda, Pedro	Plant Science—Genetics—Plant Breeding	Iowa State University
Rodríguez García, Ariel	Plant Science—Pathology	Cornell University
Rodríguez Valdez, Antonio Eliseo	Plant Science—Pathology	Purdue University
Romero Cova, Sebastian	Plant Science—Pathology	West Virginia University
Sánchez Durón, Arturo	Plant Science—Agronomy	University of Wisconsin
Silos Alvarado, José S.	Agricultural Economics	Cornell University
Velasco, Marcial	Animal Science—Nutrition—Breeding	Oklahoma State University
Wing Martínez, Marco Antonio	Plant Science—Genetics—Plant Breeding	University of Nebraska

Awarded for Study at the Mexican Agricultural Program

NAME	FIELD	COUNTRY
Carvalho, Silvio de Magalhaes	Agricultural Extension	Brazil
de Souza, Geraldo Estrazulas Pereira	Plant Science—Agronomy	Brazil
Felix Barrera, Anibal	Plant Science—Pathology	Peru
García Osegueda, Waldemar	Plant Science—Pathology	Guatemala
Larrea Herrera, Pablo Enrique	Plant Science—Genetics—Plant Breeding	Ecuador
Miranda, Luis Torres	Plant Science—Genetics—Plant Breeding	Brazil

NAME	FIELD	COUNTRY
Pacheco Veloz, Rafael	Soil Science	Ecuador
Rossi, Juan Carlos	Plant Science—Genetics—Plant Breeding	Argentina
Said, Wander	Agricultural Education	Brazil
Sánchez Campos, Hugo Eduardo	Plant Science—Genetics—Plant Breeding	Peru
Teixeira Primo, Armando	Plant Science—Agronomy	Brazil
Voysest Voysest, Oswaldo	Plant Science—Genetics—Plant Breeding	Peru

AWARDS FROM OTHER INSTITUTIONS AND ORGANIZATIONS

NAME	FIELD	PLACE OF STUDY
	Argentina	
Experimental Station, Balcarce		
Lopez Saubidet, Carlos Alfredo	Animal Science—Breeding	Iowa State University
Institute of Phytotechnology, Castelar		
Castronovo, Alfonso Jorge Pedro	Plant Science—Genetics—Plant Breeding	University of California, Davis
Favret, Ewald Alfredo	Plant Science—Genetics—Plant Breeding	Forest Research Institute, Stockholm, Sweden; Swedish Seed Association, Svalof
Rodríguez, Argos Argentino	Plant Science—Genetics	University of Virginia
National Institute of Agricultural and Livestock Technology, Buenos Aires		
Griot, Mario	Agricultural Extension	Cornell University
	Australia	
Commonwealth Scientific and Industrial Research Organization, Canberra		
Appleby, Cyril A.	Biochemistry	Brandeis University, Waltham, Massachusetts
Commonwealth Scientific and Industrial Research Organization, Adelaide		
Tiller, Kevin George	Soil Science	Cornell University
University of Queensland, Brisbane		
Colbran, Robert Chester	Plant Science—Pathology	University of California, Berkeley

NAME	FIELD	PLACE OF STUDY
Bolivia		
Inter-American Agricultural Service, Cochabamba		
Cabrera Iporre, Máximo	Plant Science—Pathology	University of Minnesota
Technical Agricultural Service of Nicaragua, Managua		
Salazar Blacud, Angel	Plant Science—Genetics—Plant Breeding	University of Nebraska
Brazil		
Agronomy Institute of the South, Pelotas		
Da Mota, Fernando Silveira	Climatology	Iowa State University
Biology Institute of Bahia, Salvador		
Fontes, Joao Tillemont	Plant Science—Economic Entomology	University of Florida
Institute of Agronomy of the State of São Paulo, Campinas		
Bernardi, Jose Botter	Plant Science—Horticulture	University of California, Davis
Da Silva, Darcy Martins	Biochemistry	University of California, Berkeley
Monaco, Lourival Carmo	Plant Science—Genetics—Plant Breeding	University of California, Davis
Institute of Biology, São Paulo		
Mariconi, Francisco de Assis Menezes	Plant Science—Entomology	University of California, Riverside
Rural University, Rio de Janeiro		
De Castro, Abeilard Fernando	Soil Science	Cornell University
Rural University of the State of Minas Gerais, Belo Horizonte		
Barbosa, Antonio Stockler	Animal Science—Nutrition	Texas Agricultural and Mechanical College
Bernis, Walter Octaviano	Veterinary Science	Texas Agricultural and Mechanical College
Chaves, Geraldo Martins	Plant Science—Pathology	University of Wisconsin
Couto, Edalmo Souza	Veterinary Science	Texas Agricultural and Mechanical College
University of Rio Grande do Sul, Pôrto Alegre		
Oliveira, Fernando Correa	Rural Sociology—Economics	University of Wisconsin
Ramos, Paulo Dias de Castro	Agricultural Engineering	University of California, Davis
University of São Paulo, Piracicaba		
Dias, Domiciano Pereira de Souza	Plant Science—Economic Entomology	University of Kansas
Falanghe, Helcio	Food Technology	University of California, Davis
Malavolta, Euripedes	Biochemistry	University of California, Berkeley

Ceylon

Department of Agriculture, Peradeniya

NAME	FIELD	PLACE OF STUDY
Alles, Wajiraransi Saddhani	Soil Science	University of Michigan
Ariyanayagam, David Veluppillai	Plant Science—Genetics—Plant Breeding	University of California, Davis
de Silva, Mervyn Dominic	Plant Science—Economic Entomology	University of California, Berkeley
Sivarajasingham, Sivasupramaniam	Soil Science	Cornell University; Soil Conservation Service, Mayaguez, Puerto Rico

Chile

Catholic University of Chile, Santiago

Norero, Aldo	Soil Science	Oregon State College
Yopo Paiva, Boris	Animal Science—Breeding	Cornell University

University of Chile, Santiago

Mancilla Cabanas, Rafael	Veterinary Science	University of Texas
Tapia Yáñez, José Ernesto	Animal Science—Breeding	University of California, Davis

University of Concepción, Concepción

Artigas Coch, Jorge	Plant Science—Entomology	Ohio State University

Colombia

Department of Extension, Ministry of Agriculture

García Brand, José	Agricultural Extension	University of Wisconsin

University of Caldas, Manizales

Idarraga Hurtado, Gilberto	Animal Science	Iowa State University
Marín Villegas, Jaime	Agricultural Engineering	University of California, Davis
Muñoz Dávila, Alvaro	Biochemistry—Pharmacology	Tulane University

Costa Rica

Inter-American Institute of Agricultural Sciences, Turrialba

Carballo Quiros, Alfredo	Plant Science—Genetics—Plant Breeding	North Carolina State College
Jiménez Saenz, Eduardo	Plant Science—Physiology	Michigan State University

Ministry of Agriculture and Industries, San José

Coto Monge, Alvaro	Plant Science—Pathology	Pennsylvania State University
Rodríguez, Ricardo A.	Plant Science—Pathology	University of Minnesota

NAME	FIELD	PLACE OF STUDY
	Ecuador	
National Wheat Commission, Izobamba		
Galárraga Galárraga, José Rafael	Plant Science—Genetics—Plant Breeding	Central University, Quito, Ecuador
	Guatemala	
Inter-American Cooperative Agricultural Service, Guatemala City		
Schieber Herbstreuter, Eugenio	Plant Science—Pathology	University of Wisconsin
	Honduras	
Pan American Agricultural School, Tegucigalpa		
Herrera S., Guillermo	Animal Science—Dairy	University of Wisconsin
Roehrs, Bernando Alfonso	Agricultural Economics	Cornell University
Sierra, Francisco Adolfo	Soil Science	University of Florida
	India	
Agricultural College and Research Institute, Gwalior		
Jethmalani, Shampal Chuharmal	Plant Science—Agronomy	Utah State University
Tamboli, Prabhakar Mahadeo	Soil Science	Iowa State University
Agricultural Research Institute, Bhagalpur		
Jha, Kali Kant	Microbiology—Bacteriology	University of Wisconsin
Agricultural Research Institute, Rajendra Nagar		
Narayan, Kishen	Plant Science—Genetics—Plant Breeding	Texas Agricultural and Mechanical College
Allahabad Agricultural Institute		
Edward, John Chinnayya	Plant Science—Pathology	University of Minnesota
Jacob, Connayil Mani	Agricultural Engineering	Iowa State University
Sundaresan, Devadason	Animal Science—Breeding	Iowa State University
Andhra Pradesh Department of Agriculture, Hyderabad		
Pillay, Trichinopoly Nataraj Dathathry	Plant Science—Horticulture	Cornell University
Balwant Rajput College, Agra		
Prasad-Singh, Sheo	Plant Science—Entomology	University of California, Davis

NAME	FIELD	PLACE OF STUDY
Bihar Department of Agriculture, Patna		
Ram, Dip Narayan	Plant Science—Agronomy	Cornell University
Bihar Department of Agriculture, Sabour		
Jha, Parmeshwari Prasad	Soil Science	Cornell University
Central Rice Research Institute, Cuttack		
Chaudhry, Mahabir Singh	Plant Science—Agronomy	Ohio State University
Patnaik, Satchidanand	Soil Science	University of California, Davis
Seetharam, Ramaswamy	Plant Science—Genetics—Plant Breeding	Louisiana State University
Central Tobacco Research Institute, Rajahmundry		
Radhakrishnamurty, Bhyravabhotla	Plant Science—Genetics	Brookhaven National Laboratory, Upton, Long Island, New York; Cornell University
Coimbatore Agricultural College and Research Institute		
Ramakrishnan, K.	Plant Science—Pathology	University of California, Riverside
Seshadri, A. R.	Plant Science—Nematology	University of California, Riverside
Coordinated Maize Breeding Scheme, Amberpet, Hyderabad		
Sankara Rao, Mandava	Plant Science—Genetics—Plant Breeding	University of Nebraska
Government College, Rupar		
Singh Sidhu, Bhag	Plant Science—Breeding	Cornell University
Indian Agricultural Research Institute, New Delhi		
Natarajan, Adayapalam Tyagaraja	Plant Science—Genetics—Plant Breeding	Brookhaven National Laboratory, Upton, Long Island, New York
Nimgade, Namdeo Marotrao	Soil Science	University of Wisconsin
Singh, Amir	Plant Science—Genetics—Plant Breeding	University of Nebraska
Srivastava, Shyamacharan	Soil Science	Cornell University
Institute of Agriculture, Anand		
Patel, Amboobhai Umedbhai	Agricultural Education	Cornell University
Patel, Ratilal Ambalal	Plant Science—Genetics—Plant Breeding	University of Arizona; University of Nebraska
Patel, Ramjibhai Madhavbhai	Biometry	North Carolina State College
Shah, Champaklal Bhogilal	Plant Science—Physiology	University of California, Davis
Institute of Plant Industry, Indore		
Anand, Satish Chandra	Plant Science—Genetics	North Carolina State College
Madhya Bharat College of Agriculture, Gwalior		
Sharma, Veda Vrata	Animal Science—Dairy	University of Minnesota

NAME	FIELD	PLACE OF STUDY
Madhya Pradesh Department of Agriculture, Gwalior		
Bindra, Onkar Singh	Agriculture—Economic Entomology	University of California, Berkeley
Model Agronomic Trials Scheme, Nasirpur, Patiala		
Sekhon, Gurcharan Singh	Plant Science—Agronomy	Iowa State University
Punjab Department of Agriculture, Ludhiana		
Kalkat, Gurcharn Singh	Plant Science—Economic Entomology	Ohio State University
Sohal, Takhat Singh	Agricultural Extension	Cornell University
State Agricultural College, Calcutta, and West Bengal Ministry of Agriculture, Calcutta		
Das, Chittaranjan	Plant Science—Pathology	Oregon State College
Tarai State Farm, Nainital District, Uttar Pradesh		
Bhatnagar, Parmanand Swarup	Plant Science—Genetics—Plant Breeding	University of Illinois
Sahni, V. M.	Plant Science—Genetics—Plant Breeding	University of Nebraska
West Bengal Ministry of Agriculture, Calcutta		
Ghose, Suva	Plant Science—Genetics—Plant Breeding	University of Minnesota
West Bengal Ministry of Agriculture, Chinsura, Hooghly		
Bhan, Kunwar Chandra	Plant Science—Horticulture	University of California, Los Angeles
West Bengal Ministry of Agriculture, Kalimpong, Darjeeling		
Roy, Narendra Nath	Plant Science—Genetics—Plant Breeding	Cornell University

Indonesia

Department of Civil Aviation, Djakarta		
Moerjono, Harry	Engineering—Aeronautics	California Institute of Technology
Faculty of Agriculture, Bogor		
Hardjodarsono, Mohammad Sunarjo	Forestry	Syracuse University
Rice Research Institute, Bogor		
Soebijanto Soemohadisepoetro, Raden	Plant Science—Physiology	National Institute of Agricultural Sciences, Tokyo, Japan

NAME	FIELD	PLACE OF STUDY
State Faculty of Agricultural Science, Pajakumbuh, Central Sumatra		
Djafar, Muhamad Ishak	Animal Science—Dairy	University of Florida
University of Indonesia, Bogor		
Hiem, Henricus Tjan Gwan	Biochemistry—Nutrition	University of California, Berkeley
Manus, Sam August	Soil Science	University of Wisconsin
Soedarmo, Djoko	Veterinary Science	Cornell University
Soeratno	Veterinary Science	Cornell University
Sosromarsono, Soemartono	Plant Science—Economic Entomology	University of California, Berkeley
Tan Hok Seng	Veterinary Science	Cornell University

Japan

NAME	FIELD	PLACE OF STUDY
Hokkaido National Agricultural Experiment Station, Sapporo		
Sakai, Hiroshi	Soil Science	North Carolina State College
Tomiyama, Kohei	Plant Science—Pathology	University of Wisconsin
Hokkaido Regional Fisheries Research Laboratory, Yoichi		
Kitano, Kiyomitsu	Marine Resources	University of Washington
Hokkaido University, Sapporo		
Anraku, Masateru	Marine Resources	Woods Hole Oceanographic Institution, Massachusetts
Hirose, Yoshitsune	Animal Science—Nutrition	Michigan State University
Hosokawa, Sadaji	Plant Science—Genetics—Plant Breeding	Colorado State University
Ogata, Shoitzu	Soil Science	University of California, Berkeley
Tsuda, Chikahiro	Plant Science—Genetics—Plant Breeding	Michigan State University
Yoshida, Tadashi	Microbiology	University of Southern Illinois
Kyoto University		
Kawaguchi, Keizaburo	Soil Science	Cornell University
Nei, Masatoshi	Agriculture—Genetics—Plant Breeding	University of California, Davis
Kyushu National Agricultural Experiment Station, Fukuoka		
Fujii, Hiroshi	Plant Science—Pathology	University of Minnesota
Kyushu National Agricultural Experiment Station, Kumamoto		
Maki, Yoshisuke	Plant Science—Agronomy	University of Wisconsin
Kyushu University		
Fujihara, Teruo	Agricultural Engineering	California Institute of Technology
Wada, Koji	Agriculture—Soil Science	University of Wisconsin

NAME	FIELD	PLACE OF STUDY
Miyazaki University		
Nakayama, Shidai	Plant Science—Physiology	United States Department of Agriculture, Beltsville, Maryland
Nagoya National University, Anjo, Aichi		
Ashida, Kiyoshi	Animal Science—Nutrition	University of Wisconsin
Kondo, Kyoji	Animal Science—Breeding	Storrs Agricultural Experiment Station, Connecticut
Kuyama, Shimpei	Agriculture—Microbiology	Rutgers University
Tasaki, Iwao	Animal Science—Nutrition	Cornell University
Uritani, Ikuzo	Biochemistry	University of Wisconsin
Yokoyama, Akira	Animal Science—Physiology	University of Reading, Shinfield, England
National Institute of Agricultural Sciences, Tokyo		
Hachinohe, Yoshio	Agriculture—Entomology	Iowa State University
Ichinohe, Minoru	Plant Science—Nematology	United States Department of Agriculture, Beltsville, Maryland
Nishi, Sadao	Plant Science—Horticulture	Cornell University
Yano, Nobuhiro	Animal Science—Dairy	Iowa State University
National Institute of Animal Health, Tokyo		
Shimbayashi, Koichi	Biochemistry	University of Wisconsin
Tohoku University, Sendai		
Tamate, Hideo	Animal Science—Nutrition	Iowa State University
Yamane, Ichiro	Soil Science	Cornell University
University of Tokyo		
Ishida, Kiichi	Veterinary Science	Michigan State University
Ogata, Manabu	Veterinary Science	University of Maryland
Satoo, Taisitiroo	Plant Science—Physiology	Duke University
Shimaji, Ken	Plant Science—Botany	Yale University

Mexico

Institute of Biology, National Autonomous University, Mexico, D.F.		
Marquez Mayaudon, Carlos	Plant Science—Economic Entomology	University of Colorado
Institute for Sugar Cane Improvement, Mexico, D.F.		
Flores Cáceres, Silverio	Plant Science—Economic Entomology	Louisiana State University
Montes Gutiérrez, Hermilo	Plant Science—Genetics—Plant Breeding	North Carolina State College
National School of Agriculture, Chapingo		
Vázquez González, José Trinidad	Plant Science—Entomology	University of California, Davis

NAME	FIELD	PLACE OF STUDY
School of Agriculture and Animal Husbandry, Institute of Technology and Superior Studies, Monterrey		
de Alba Flores, Gabino	Plant Science—Genetics	Purdue University
Mathieu Veillard, Jean	Animal Science—Entomology	University of Illinois
Morales Ramos, Daniel	Soil Science	Cornell University
University of Sonora, Hermosillo		
Hidalgo-Arrecillas, Raúl	Animal Science—Poultry	Texas Agricultural and Mechanical College

National Republic of China, Taiwan

Chinese-American Joint Commission on Rural Reconstruction, Taipei		
Lee, Robert Chung Tao	Veterinary Science	Cornell University

Nicaragua

Ministry of Agriculture and Livestock, Managua		
Kraemer, Paul	Plant Science—Entomology	University of California, Berkeley
Lizárraga Herrera, Joaquín Héctor	Soil Science—Fertility	North Carolina State College

Nigeria

University College, Ibadan		
Hill, Desmond Hayward	Animal Science—Physiology—Breeding	Louisiana State University; University of São Paulo, Brazil

Pakistan

Punjab Agricultural College, Lyallpur		
Bhatti, Mohammad Bakhsh	Food Technology	Massachusetts Institute of Technology
Khan, Muhammad Abdullah	Plant Science—Genetics	Iowa State University
Latif Rasulpuri, Muhammad	Food Technology	Oregon State College
Department of Agriculture		
Said, Mian	Plant Science—Horticulture	University of California, Los Angeles
Shafi, Ch. Muhammad	Plant Science—Genetics—Plant Breeding	University of Minnesota
Yaqub Chawdhry, Muhammad	Plant Science—Genetics	University of Wisconsin; University of Arizona

NAME	FIELD	PLACE OF STUDY
Ministry of Food and Agriculture, Karachi		
Hassan, Muhammad Amjad	Soil Science	University of Illinois
University of Karachi		
Mahmood, Syed Hamid	Plant Science—Economic Entomology	North Carolina State College
Peru		
Agrarian University (formerly the National School of Agriculture), Lima		
Grobman, Alexander	Plant Science—Genetics	Harvard University
Salhuana MacKee, Wilfredo Sergio	Biometry	North Carolina State College
University of San Marcos, Lima		
Copaira Beltrán, Marcos	Veterinary Science	University of Minnesota
Fernández Baca, Saul	Animal Science—Dairy	University of California, Davis
Lombardi Lombardi, Max	Veterinary Science	Cornell University
Philippines		
Bureau of Animal Industry, Manila		
Bandong, Francisco C.	Animal Science—Breeding—Poultry	Texas Agricultural and Mechanical College
Bureau of Plant Industry, Manila		
Andes, Bienvenido C.	Agricultural Engineering	Oklahoma State University
Castillo, Bernardo S.	Plant Science—Pathology	University of Minnesota
Garcia, Glicerio Maluyo	Plant Science—Genetics—Plant Breeding	Texas Agricultural and Mechanical College
Bureau of Public Schools, Manila		
Quirolgico, Delfin G.	Education	Stanford University
Central Luzon Agricultural College, Nueva Ecija		
Abella y Aguilar, Pedro	Plant Science—Agronomy	University of Florida
Irabagon, Teodore A.	Plant Science—Genetics—Plant Breeding	North Carolina State College
Juliano, Jorge Patriarca	Plant Science—Pathology	University of California, Davis
Villaviza y Nimes, Quirino	Biometry	Iowa State University
Forest Products Research Institute, Laguna		
Avanzado, Norma Arlac Abigania	Agriculture—Forestry	University of Wisconsin
Mindanao Agricultural College, Bukidnon		
Pepito, Narciso N.	Animal Science—Breeding—Nutrition	Oklahoma State University

NAME	FIELD	PLACE OF STUDY
Plurad, Santiago Bacani	Plant Science—Economic Entomology	Iowa State University
Rivera, Celestino T.	Plant Science—Economic Entomology	University of Maryland
Roquia, Felixberto D.	Plant Science—Horticulture	Utah State University
Zablan, Florendo Flores	Agricultural Economics	Cornell University
Philippine Atomic Energy Commission, Manila		
Valencia, Iluminado G.	Soil Science	University of Wisconsin
University of the Philippines, Los Baños, Laguna		
Alfonso, Pablo J.	Animal Science—Zoology	Colorado State University
Bernardo, Fernando Apelo	Plant Science—Genetics—Plant Breeding	North Carolina State College
Borja, Concordia Rivera	Agriculture—General (Chemistry)	Purdue University
Cadiz, Teodoro G.	Plant Science—Horticulture	Louisiana State University; Cornell University
Calora, Feliciano Banaag	Plant Science—Entomology	Cornell University
Castillo, Leopoldo S.	Animal Science—Dairy	Cornell University
Davide, Jorge G.	Soil Science	North Carolina State College
de Guzman, Emerita V.	Plant Science—Physiology	Cornell University
Escuro, Pedro B.	Plant Science—Genetics—Plant Breeding	University of Minnesota
Flores, Thomas Gobaton	Agricultural Extension	University of Wisconsin
Juliano, Rogelio Ochoa	Marine Resources	University of Michigan
Lantican, Ricardo Manzo	Plant Science—Genetics—Plant Breeding	Iowa State University
Oñate, Luz U.	Home Economics—Foods	Iowa State University
Saguiguit, Gil Franco	Agricultural Education	Pennsylvania State University
San Juan, Mario O.	Plant Science—Pathology	University of Wisconsin
Sison, Obdulia E. Fronda	Agricultural Education	Cornell University
	Poland	
Agricultural Academy, Wroclaw		
Lidtke, Wlodzimierz	Plant Science—Agronomy	McGill University, Canada
Central College of Agriculture, Warsaw		
Fitko, Remigiusz	Veterinary Science	University of Montreal, Canada
Horubala, Adolf	Biochemistry	University of Massachusetts; New York State Agricultural Experiment Station, Geneva
Jakubczyk, Tadeusz	Food Technology	Massachusetts Institute of Technology; University of California, Davis
Moskal, Stanislaw Andrzej	Soil Science	University of Wisconsin; United States Department of Agriculture, Beltsville, Maryland
Nowosielski, Olgierd Aleksander	Soil Science	University of Wisconsin; University of Bristol, England

NAME	FIELD	PLACE OF STUDY
Central School of Rural Economics, Warsaw		
Dluzewski, Mieczyslaw	Microbiology—Bacteriology	Federal Research Institute for Dairy Farming, Bern, Switzerland; National Institute for Research in Dairying, Shinfield, England
College of Agriculture, Cracow		
Figula, Kazimierz	Soil Science	Federal Technical Institute, Laboratory of Agricultural Technology, Zurich, Switzerland
Miczynski, Kazimierz	Plant Science—Physiology	Rothamsted Experimental Station, Harpenden, England; Cornell University
Samotus, Boguslaw	Biochemistry	United States Department of Agriculture, Albany, California
College of Agriculture, Lublin		
Bezubik, Bernard	Animal Science	United States Department of Agriculture, Beltsville, Maryland
Oktaba, Wiktor	Agriculture	Iowa State University
Pinkiewicz, Edward	Veterinary Science	Clinic for Internal Diseases of Animals, Vienna, Austria
Prost, Edmund	Veterinary Science	Federal Research Institute for Animal Husbandry, Kulmbach, Germany
Strzelczyk, Edmund	Microbiology—Bacteriology	Microbiology Research Institute, Central Experiment Farm, Ottawa, Canada
College of Agriculture, Poznan		
Glaser, Tadeusz	Plant Science—Horticulture	Institute for Fruit Tree Diseases, Heidelberg, Germany
Szymanski, Stefan	Plant Science—Physiology	Institute of Soil Biochemistry, Agricultural Research Center, Brunswick, Germany
College of Agriculture, Warsaw		
Starck, Jan Roman	Agricultural Sciences	University of Wisconsin
Witczak, Franciszek	Animal Science—Nutrition	College of Agriculture, Copenhagen, Denmark
Experimental Farm for Animal Breeding, Grodziec		
Okonski, Jerzy	Animal Science—Physiology	Cornell University
High School of Agriculture, Lublin		
Gluchowski, Witold	Animal Science—Poultry	Technical University, Swiss Federal Institute of Technology, Zurich, Switzerland

NAME	FIELD	PLACE OF STUDY
Higher School of Agriculture, Cracow		
Pigon, Halina	Animal Science—Physiology	University of California, Davis; Veterinary College of Norway, Oslo
Higher School of Agriculture, Poznan		
Blaszczak, Wladyslaw	Plant Science—Pathology	University of Wisconsin; Cornell University
Skupin, Janusz Stanislaw	Biochemistry	Rockefeller Institute, New York
Szmidt, Alfred	Plant Science—Economic Entomology	Institute of Biological Pest Control, Darmstadt, Germany
Institute of Agriculture, Pulawy		
Doruchowski, Roch Wlodzimierz	Plant Science—Genetics—Plant Breeding	University of Wisconsin
Institute of Grasslands and Amelioration, Warsaw		
Okruszko, Henryk	Soil Science	Purdue University
Institute of Inland Water Fisheries, Warsaw		
Backiel, Tadeusz	Marine Resources	University of Washington
Institute of Plant Physiology, Warsaw		
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Institute of Plant Protection, Poznan		
Boczek, Jan	Plant Science—Economic Entomology	University of Kansas; University of Maryland
Grela, Tadeusz Boleslaw	Plant Science—Pathology	University of California, Berkeley
Lipa, Jerzy Jozefat	Plant Science—Economic Entomology	University of California, Berkeley
Institute of Pomology, Skierniewice		
Leski, Ryszard Artur	Plant Science—Entomology	University of Minnesota; University of California, Riverside
Wiackowski, Stanislaw Kazimierz	Animal Science—Entomology	University of California, Riverside
Institute of Soil Management and Plant Cultivation, Pulawy		
Kabata, Alina	Soil Science	Cornell University
Wrobel, Tadeusz	Microbiology—Bacteriology	University of Wisconsin
Maria Curie-Sklodowska University, Lublin		
Lorkiewicz, Zbigniew Konstanty	Genetics	Rutgers University
Plant Breeding and Acclimatization Institute, Pulawy		
Blaim, Kazimierz	Biochemistry	University of Zurich, Switzerland

NAME	FIELD	PLACE OF STUDY
Ruszkowski, Marek	Plant Science—Genetics—Plant Breeding	University of Minnesota
Plant Breeding Institute, Bydgoszcz		
Pawelska, Krystyna	Plant Science—Entomology	Rothamsted Experimental Station, Harpenden, England
Plant Breeding Station, Bydgoszcz		
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Szota, Zdzislaw	Plant Science—Genetics—Plant Breeding	Colorado State University
Polish Academy of Sciences, Poznan		
Jaranowski, Julian Kazimierz	Plant Science—Genetics—Plant Breeding	University of Wisconsin
Wiewiorowski, Maciej	Biochemistry	National Research Council, Ottawa, Canada
Polish Academy of Sciences, Skierniewice		
Bojanowski, Jan	Plant Science—Genetics	Iowa State University
Chmielewski, Tadeusz	Plant Science—Genetics—Plant Breeding	University of California, Davis
Skapski, Henryk	Plant Science—Horticulture	Cornell University
Polish Academy of Sciences, Warsaw		
Poczopko, Piotr	Animal Science—Physiology	New York University
State Institute of Hygiene, Warsaw		
Bartnik, Jan Marian	Biochemistry—Nutrition	University of Wisconsin
Rakowska, Maria Grekowicz	Animal Science—Nutrition	University of Wisconsin; Cornell University
Zaleski, Jan Henryk	Food Technology	Massachusetts Institute of Technology
University of Warsaw		
Szynkiewicz, Zbigniew Marian	Microbiology—Bacteriology	Western Reserve University, Cleveland, Ohio
Veterinary Institute of Pulawy		
Grundboeck, Marian	Veterinary Science	University of Wisconsin
Juszkiewicz, Teodor	Veterinary Science	Iowa State University
Zebrowski, Leon	Animal Science	University of North Carolina
Warsaw Polytechnic Institute of Mechanization and Electrification of Agriculture, Warsaw		
Bernacki, Henryk	Agricultural Engineering	Institute for Fundamental Research in Agricultural Engineering, Brunswick, Germany
Pabis, Stanislaw	Agricultural Engineering	University of California, Davis

NAME	FIELD	PLACE OF STUDY
	Scotland	
Agricultural Research Council Poultry Research Centre, Edinburgh		
Wood-Gush, David G. M.	Animal Science—Physiology	Cornell University
	Sweden	
University of Lund		
Lima de Faria, Antonio Jose Cortesao Pais	Plant Science—Genetics	University of Illinois; Institute for Cancer Research, Philadelphia
	Thailand	
Kasetsart University, Bangkok		
Chindavanig, Supis	Biochemistry—Nutrition	University of Wisconsin
Chutima, Krisna	Biochemistry	Purdue University
Intrama, Siriphong	Plant Science—Pathology	Oregon State College; University of Minnesota
Khatikarn, Bunjird	Plant Science—Horticulture	Utah State University
Pichaicharnarong, Ayusa	Animal Science—Physiology	Cornell University
Poolsup, Maitri	Agricultural Engineering	Utah State University
Smitananda, Phanom	Agricultural Education	Cornell University
Ministry of Agriculture, Bangkok		
Kanjanasoon, Prakob	Plant Science—Pathology	University of Minnesota
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Tennessee Valley Authority, Wilson Dam, Alabama		
Brown, Walter Eric	Soil Science	University of Amsterdam, Netherlands
	Uruguay	
Faculty of Agronomy, Salto		
García Cabrera, Diomedes Claro	Plant Science—Agronomy	University of Florida

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ANNUAL REPORT
1960–1961

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Peter R. Jennings, PH.D., *Associate Geneticist*
Charles F. Krull, PH.D., *Assistant Geneticist*
Jerome H. Maner, PH.D., *Assistant Animal Scientist*
A. Colin McClung, PH.D., *Soil Scientist*
Robert F. Ruppel, PH.D., *Entomologist*
H. David Thurston, PH.D., *Plant Pathologist*
David H. Timothy, PH.D., *Associate Geneticist*

CHILEAN AGRICULTURAL PROGRAM

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Paul J. Fitzgerald, PH.D., *Geneticist*
Arthur D. Leach, Jr., PH.D., *Associate Agricultural Engineer*
Donald L. McCune, PH.D., *Agronomist*
Robert W. Romig, PH.D., *Geneticist*

INDIAN AGRICULTURAL PROGRAM

Ralph W. Cummings, PH.D., *Director*
Guy B. Baird, PH.D., *Assistant Director*
Leland R. House, PH.D., *Associate Geneticist*
Alvin A. Johnson, M.S., *Seed Production Specialist*, *Temporary Staff Member*
Kenneth O. Rachie, PH.D., *Geneticist*
Ernest W. Sprague, PH.D., *Geneticist*
Jack D. Traywick, M.S., *Associate Agricultural Engineer*

INTER-AMERICAN FOOD CROP IMPROVEMENT PROGRAM

Norman E. Borlaug, PH.D., *Director, Inter-American Wheat Improvement Project*
John S. Niederhauser, PH.D., *Director, Inter-American Potato Improvement Project*
Edwin J. Wellhausen, PH.D., *Director, Inter-American Maize Improvement Project*

INTERNATIONAL RICE RESEARCH INSTITUTE

Robert F. Chandler, Jr., PH.D., *Director*
Sterling Wortman, PH.D., *Assistant Director*
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Loyd Johnson, M.S., *Agricultural Engineer*

THE ROCKEFELLER FOUNDATION

Program in the

Agricultural Sciences

Director's Introduction

The program in the Agricultural Sciences of The Rockefeller Foundation has been under way for 18 years. Cooperative efforts of other private and public organizations to improve agricultural technology in less well-advanced areas also have moved into the second decade of operation. This accumulated experience supplies a basis for evaluating technics and for realignment of support and cooperative efforts for the future.

Many of the problems in the less well-advanced areas of the world have changed in scope, complexity, and urgency as populations have expanded and as new nations have emerged. It is generally recognized that the direct transfer of materials and practices from the temperate zone agriculture of the United States is possible only to a limited extent and it is increasingly apparent that programs of research and testing must be conducted within the host country to ensure the development of practices that may be adopted without undue risk by local farmers. The agricultural technology that has been achieved in the United States, which enables less than 10% of our population to supply in abundance our needs for agricultural products, evolved from decades of research in which thousands of scientists cooperated in well-organized and effectively directed regional and national programs. It is doubtful whether reasonable progress can be achieved in the less well-advanced agricultural areas of the world without a similarly organized and sustained effort.

The intellectual and material resources of agricultural research and educational centers in the United States have been channeled through Foundation field staff scientists in the cooperating programs to speed up agricultural progress in the host countries. In return, new information and materials derived from the Foundation's widespread technical cooperation activities promise to add new dimensions to the agriculture of the already well-advanced nations. For example, the information on the host range and sources of resistance to the "hoja blanca" disease of rice and on the agents for its transmission, and the information being gathered on the virulence of a recently discovered race of stem rust of oats in Colombia will have broad potential impact on world production of these crops.

A significant factor in the remarkable advance in productivity and efficiency of agriculture in the United States is the cooperative research effort of the Department of Agriculture and the land-grant colleges and universities. These institutions, over the past hundred years, have achieved a unique pattern of attention to problems of local, regional, and national significance. The extension of cooperation in agricultural science and technology to international dimensions holds rich promise for advancing human welfare throughout the world.

The general purposes and procedures of The Rockefeller Foundation's program in the agricultural sciences were outlined in the Annual Report for 1959-1960. These activities are concerned primarily with the improvement of food production in the less-advanced agricultural areas of the world through cooperative projects in research, education, and extension, designed to improve materials and practices adapted to specific indigenous environments; through the training of local personnel for future leadership in agricultural science and technology; and through the cooperative development of indigenous organizations or institutions that may carry on research, education, and extension activities related to agriculture.

The Foundation's operating programs, in which employees of the Foundation are located in the host country to furnish leadership for selected research projects, have been under way since 1943 when the first such program was established in cooperation with the Ministry of Agriculture in Mexico. The results of this cooperative effort are measurable in terms of increased yields, in the achievement of self-sufficiency in Mexico for corn, wheat, and other agricultural commodities, and in the evolution of more effective and efficient practices for disease and pest control, fertilizer and water use, and soil management. During the 18 years, nearly 600 scientists have received training of an in-service nature through association with the country-wide research activities, 32 Mexican scientists have earned or are earning their Ph.D. degree, and 104 the Master of Science degree under the Foundation's fellowship and scholarship awards.

The ultimate objective of the cooperative field programs is the establishment of an indigenous organization that will permit continuing advances in agricultural technology under the leadership of trained local scientists. The National Institute of Agricultural Research, established in Mexico in January, 1961, under a decree of President Adolfo López Mateos, consolidated the former Office of Special Studies with other research units in the Ministry of Agriculture.

The leadership of specific research projects, for improvement of horticultural crops, beans, wheat, and potatoes, for plant pathology, and for direction of the library, had been transferred to trained Mexican colleagues over a period of several years. The new research organization places major responsibility for technical and administrative matters in the hands of the Mexican scientists, with the head of The Rockefeller Foundation field staff designated as Codirector. The administration of research in the new organization will present certain problems because of some loss of flexibility in budget and fiscal procedures as major financing is furnished from local sources. The continued success of the agricultural research program in Mexico will depend largely, however, on retention of sufficient freedom of decision and maneuverability to permit timeliness of operation of research. Competent and well-trained scientists can be rendered ineffective by excessive administrative limitations, and Foundation staff in Mexico are assisting in development of organization and procedural patterns to assure the continuation of an effective research program to serve Mexican agriculture as Foundation participation diminishes in the years ahead.

The Rockefeller Foundation has provided substantial support for the construction of facilities and for equipment for the headquarters and selected field research centers of the new National Institute of Agricultural Research. The Foundation has also supplied financial aid for the further development of the Graduate School of the National School of Agriculture at Chapingo, recognizing that the education of agricultural scientists must be increasingly undertaken by local institutions if the expanding needs for trained personnel are to be met by the country in the future. The Graduate School at Chapingo awarded its first M.Sc. degrees to 10 students in June, 1961. Several years of continued cooperation will undoubtedly be helpful in Mexico to assure the effective development of the Graduate School.

The cooperating programs in Colombia and Chile are still emerging, with the full complement of Foundation staff now employed for the cooperation mutually agreed upon in Colombia. In this country, emphasis is being given to the development of research in the animal sciences, a project that is also supported substantially by the United States government through the use of funds accumulated from the sale of surplus agricultural commodities, under Public Law 480. The cooperation in both Colombia and Chile has been well integrated with the research units of the respective Ministries of Agriculture.

The operating program in India, which is concerned with the improvement of maize, sorghums, and millets, and also with the development of postgraduate training in the agricultural sciences, was established in close relationship with the organizations and institutions having local responsibility for these types of activities. The creation of four corn hybrids adapted to the major corn-growing regions of India within the short span of four years since this cooperative effort was initiated, is rather striking evidence of the rapidity with which improvements may be achieved through well-directed and broadly planned research. The new hybrids, which will be grown in the hill regions of the Himalayas, in the Gangetic Plain, and in South India, are expected to yield 56% to 80% more than native varieties. Efforts are now being directed toward the development of a seed production and marketing organization to assume responsibility for increase and distribution not only of maize seed but also of other improved crop seeds throughout the country.

The Post Graduate School was inaugurated at the Indian Agricultural Research Institute in October, 1958. With an enrollment of about 180 candidates for the Ph.D. and of approximately 170 for the M.Sc. degree each year, the Post Graduate School promises to make a substantial contribution to the development of qualified personnel for India's increasing agricultural technology.

The International Rice Research Institute, now being established at Los Baños in the Philippines, in cooperation with the College of Agriculture of the University of the Philippines and with support from the Ford Foundation for construction of buildings and facilities, is governed by its own Board of Trustees. The activities of the Institute are reviewed in this report, since certain key personnel of the Institute are furnished by the Foundation and the operating funds also will be supplied largely by the Foundation.

The Inter-American Food Crop Improvement Program is still in the embryonic stage and has been expanded to include attention to potato improvement during the past year, in addition to the earlier activation of hemisphere-wide activities on corn and wheat improvement. This new type of Foundation program provides a very promising pattern for maximizing the effectiveness of the application of Foundation staff and funds.

Grants or appropriations from The Rockefeller Foundation to support research and teaching are being made with increasing attention to the selection of those institutions in the United States and in other agriculturally advanced countries that are conducting projects of mutual concern with the Foundation's operations overseas, or research of a fundamental nature of broad potential value.

The Foundation is extending cooperative assistance to selected international programs of research and development. An example is the appropriation to the Food and Agriculture Organization of the United Nations for fellowships. This award will enable 25 to 30 young scientists from 11 countries in the Near East region who are participating in the FAO-coordinated wheat and barley improvement project, to receive in-service training in the cooperating programs in Mexico and Colombia during the next five years. Another is the appropriation to North Carolina State College to support fundamental research in genetics and, more specifically, to direct the training of Latin American students in corn breeding, to enhance the depth of understanding of these future scientists of the principles involved in crop improvement in the Americas.

Financial Summary

Program in the Agricultural Sciences

1941 through 1960

OPERATING PROGRAMS

Mexico	$7,316,713	
Colombia	3,787,219	
India	2,282,250	
Chile	1,808,182	
Central American Corn Improvement Program	247,548	
Philippines	312,061	
Inter-American Food Crop Improvement Program	250,705	
General	205,969	$16,210,647

FELLOWSHIPS AND SCHOLARSHIPS

Fellowships		
Regular Program	$2,904,873	
Expanded Program	2,418,727	
Polish Science Program	193,263	
Latin America—Scholarships	1,169,308	
Mexico—Scholarships	291,997	6,978,168

GRANTS PROGRAM

United States	$6,316,010	
South America	4,751,686	
The Far East	3,649,641	
Mexico	1,606,441	
Europe	906,084	
Africa	825,176	
Philippines	730,551	
Central America	453,010	
Near East	237,950	
Canada	10,622	
General	109,712	19,596,883
Total grants, 1941 through 1960		$42,785,698

Mexican Agricultural Program

Personnel

MINISTRY OF AGRICULTURE

His Excellency, **Don Julián Rodríguez Adame,** ING. AGR., Minister of Agriculture
Jesús Patiño Navarrete, ING. AGR., Subsecretary of Agriculture
Daniel Mercado García, D.V.M., Subsecretary of Livestock
Esteban Uranga Prado, ING. AGR., Executive Officer

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Roderic E. Buller, PH.D., Agronomist
Donald K. Freebairn, PH.D., Associate Agricultural Economist
Daniel D. Hagen, D.V.M., Animal Pathologist
Elmer C. Johnson, PH.D., Geneticist
Reggie J. Laird, PH.D., Soil Scientist
Neil B. MacLellan, Staff Photographer
Delbert T. Myren, PH.D., Information Specialist
John S. Niederhauser, PH.D., Plant Pathologist (until January, 1961)
William R. Young, PH.D., Associate Entomologist

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VARIETAL IMPROVEMENT IN SMALL GRAIN CROPS

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Raúl Robles S., ING. AGR., Investigator, Culiacán
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MAINTENANCE AND DEVELOPMENT

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Farmers inspect a model home garden during a field day at Cotaxtla.

Director's Introduction

Agricultural research in Mexico is undergoing extensive technical and administrative modifications as a direct result of a decree signed by President Adolfo López Mateos on December 5, 1960. This presidential decree established the National Institute of Agricultural Research (Instituto Nacional de Investigaciones Agrícolas, "INIA") as a dependency of the Ministry of Agriculture through the fusion of the Institute of Agricultural Research and the Office of Special Studies. It further established headquarters for the National Institute at the site of the National School of Agriculture, Chapingo, Mexico. However, until satisfactory facilities are developed at Chapingo, central offices for the National Institute are being maintained at Londres 40, Mexico, D.F.

Coordination and unification of programs of investigation in agriculture within a single National Institute represents a significant forward step toward the effective resolution of Mexico's agricultural problems. It also represents partial fulfillment of certain original objectives of the cooperative research program being reported herein. It appears pertinent therefore at this stage of development of the Mexican Agricultural Program, to review briefly the original concepts and objectives as defined when the cooperative program was established between The Rockefeller Foundation and the Government of Mexico.

The chief objective was to increase the quantity and quality of food crops of major importance in Mexico, by means of clearly defined projects of research and experimentation on such crops in the principal agricultural areas of Mexico. Concurrently with research and experimentation went an intensive training program, conducted locally in the form of direct participation in project planning and research, and internationally through scholarships, fellowships, and travel grants for further study and experience at universities and other institutions. This training program was designed to accomplish two ends: to advance local research and experimentation as rapidly as possible and, of even more long-term importance, to prepare competent, well-trained scientists to assume the leadership in agricultural research and education in Mexico.

Grants have also been made available by The Rockefeller Foundation to selected universities, schools of agriculture, and other institutions in Mexico for the support of education and research in the agricultural sciences. Such grants have assisted in the development of stronger institutions and have added to the body of scientific knowledge relating to agriculture.

It has been the intention of The Rockefeller Foundation in this cooperative venture to assist in the development of a strong, national agricultural research organization.

Agricultural research has become recognized as vital to national progress, scientists have been trained to assume the major responsibilities for research, and the grant program has strengthened Mexican institutions associated with research and education.

These accomplishments have aided in bringing about the establishment of the National Institute of Agricultural Research, which as mentioned above, was created this year.

This brief review points out in general terms the progress made in the realization of the original objectives and provides a basis for an evaluation of the present stage of development and orientation for future evolution.

Plant improvement and animal industry projects in cooperation with the related disciplines of soil science, plant and animal pathology, entomology, economics, and agricultural information, have significantly increased national production of basic foods in Mexico and have resulted in definite improvement in the economy and nutrition of the Mexican people. Associated with this agricultural progress are concurrent developments such as the more effective utilization of water resources, better credit facilities, greater machinery production and importation, improved communications and marketing facilities, and increased production of fertilizers, fungicides, and insecticides, which together have resulted in a prospering, dynamic national agriculture.

Procedures for realizing these objectives have naturally been subject to considerable modification over the years and the flexibility of such procedures, by permitting adaptation to changing conditions, has made it possible to maintain a harmonious relationship between research projects and national agricultural needs.

The unification of personnel, physical installations, equipment, and plant materials, as well as an expanded federal budget for research, should result in a more effective resolution of national production problems. Since the new organization is charged with research on fiber and export crops, as well as on basic food crops, such unification should bring about a well-balanced program of investigation of agricultural problems of major importance to Mexico.

It is clearly apparent that recent advances in agricultural research, as translated into improved quality and quantity of foodstuffs, could not have been realized without adequately trained personnel. It is worthy of special mention that complete responsibility for research in the fields of small grains improvement, horticulture, bean and soybean improvement, plant pathology, and potato improvement has been turned over to capable young Mexicans during the past two years, and previously assigned Rockefeller Foundation personnel given other responsibilities. This progress in the training program has recently been strengthened by the establishment of the Graduate School at Chapingo and the initiation of postgraduate studies at the Technological Institute and School of Advanced Studies of Monterrey. Now and in the future it should be possible to increase the number of trained research personnel and, perhaps more important still, to provide such training in Mexico.

A shortage of trained, experienced personnel in some fields of investigation within the new organization's expanded responsibilities, represents a serious problem for the immediate future. However, it is expected that the same philosophy of effective training which was characteristic of the Office of Special Studies will continue and expand, in order to cope with the demand for additional personnel.

Experiment station development moved ahead significantly during this past year with approval by the Minister of Agriculture for the establishment of the Center for Agricultural Research for the Bajío at Roque, Guanajuato. This center, now in the process of rapid development, is strategically situated in the heart of the important agricultural region known as the Bajío. Conditions of soil, climate, and communications are all favorable and should permit wide application of research results from this center. Construction and land preparation have moved along rapidly in spite of a delayed start. Two wells have been drilled and are functioning, of the six planned. Construction of shops and minimal storage facilities has been completed. Road systems have been laid out. Construction is terminating on one-third of the three-section main building which houses laboratories and offices. Approximately 65 hectares were prepared and seeded to summer crops this year.

GRADUATE SCHOOL, CHAPINGO

Considerable emphasis has been placed on the continuous development and strengthening of this recently established Graduate School. More than 20 students have received the Master of Science degree during the past year. These men now occupy positions of responsibility in research and teaching in institutions related to agriculture. After more than two successful years of operation the Graduate School has an impressive record of accomplishment. Thesis and other publications are appearing, reporting the results of the research work undertaken by staff and students. Laboratory, library, and greenhouse facilities are being expanded and improved. While the El Horno experiment station has cooperated since the establishment of the School in providing laboratory space and field plot facilities for cooperative research ventures, the experimental lands of the National School of Agriculture have also been developed and expanded with the Graduate School to permit increased research. Staff of the Graduate School have been instrumental in bringing about closer relationships between the undergraduate schools of agriculture in the Republic through regularly scheduled meetings with faculties of the schools and by providing advanced or refresher courses for staff during vacation periods. The participation of graduate staff in undergraduate teaching at the National School of Agriculture at Chapingo has contributed to the strengthening of that institution.

Staff of the old Office of Special Studies and now of the National Institute of Agricultural Research have participated directly in the teaching program and will continue to provide assistance in teaching and research counseling.

The Graduate School is developing into an institution which will effectively serve the needs of Mexico in providing advanced training in agriculture, and it is expected that further sound growth will permit participation in regional and even hemispheric responsibilities in this field. With close cooperative programs also established by the Inter-American Food Crop Program in corn, wheat, and potato research, a center of operations is being established at the School which should bring about more effective advancement in the resolution of agricultural problems in Mexico and also in other Latin American countries.

GENERAL ACTIVITIES

With the recent initiation of international food crop improvement projects within a framework of increased emphasis on certain basic food crops in the Americas, Dr. John S. Niederhauser assumed new responsibilities for potato improvement under the Inter-American Food Crop Improvement Program. Although Dr. Niederhauser will continue to headquarter with the Mexican Agricultural Program and be available to staff for advice and counsel, his direct intervention in planning and execution of local projects in plant pathology and potato improvement will be missed.

Two capable, well-trained Mexican scientists have now been named to carry on and advance these research programs. Dr. Antonio Rodríguez, recently returned from Purdue University, has now assumed complete responsibility for plant pathology research in the National Institute of Agricultural Research. Dr. Javier Cervantes, who returned in December, 1960, from the University of Wisconsin, is now directing all potato improvement research in the National Institute.

The Agricultural Consultants of The Rockefeller Foundation, together with officers from New York and Field Directors from Colombia, Chile, and India, met in Mexico, July 25 to 30, 1960. This was a particularly stimulating experience for staff of the Mexican Agricultural Program since it provided the opportunity of personally reviewing local work programs with these scientists.

TEMPORARY STAFF AND SCIENTIFIC AIDES

The program was fortunate in obtaining the services of several outstanding scientists on temporary appointments during the past year. Significant contributions continue to develop from the program of temporary assignments in the fields of research and training.

Dr. E. C. Stakman visited the Mexican Agricultural Program twice during the past year, from October 3 to December 10, 1960, and from March 13 to June 3, 1961, in his official capacity of Special Consultant for Agricultural Sciences. His active participation on both occasions in the teaching and research programs of the Graduate School at Chapingo was particularly helpful to staff of both the School and the Program in further effecting closer coordination of activities and in stimulating development of improved teaching and research methods.

Dr. H. L. Everett, Associate Professor, Department of Plant Breeding, Cornell University, was appointed Temporary Staff Member of the Mexican Agricultural Program on January 10, 1961, for a period of one year. Dr. Everett is assisting principally in development of teaching programs in the plant breeding department of the Graduate School at Chapingo, in addition to providing guidance and counsel in graduate student research problems.

Dr. Albert E. Longley, cytogeneticist of Columbia, Missouri, formerly connected with the Agricultural Research Service, U. S. Department of Agriculture, was appointed Special Temporary Scientific Aide with the program for a six-month period beginning March 27, 1961. During this second assignment, Dr. Longley continues working in the teaching and research programs at the Graduate School, with particular emphasis on research in the cytogenetics of maize.

Dr. E. P. Whiteside, Professor of Soil Science, Michigan State University, East Lansing, was appointed Special Temporary Scientific Aide for a period of three months beginning March 31, 1961. Dr. Whiteside has initiated a study of the classification of soils into Great Groups in the tropical southeastern region of Mexico. It is planned that this study will be continued by competent local personnel and through further assistance from Dr. Whiteside in the future in order ultimately to establish a national soil classification program.

VISITORS ON ROCKEFELLER FOUNDATION TRAVEL GRANTS

Dr. Ferruccio Accame, Dean, Faculty of Zoology, Agrarian University, Lima, Peru.

Ing. Claudio Vergara, Director of Agricultural Research, Ministry of Agriculture, Santiago, Chile.

Ing. Mario Vallejo, Director, Central Experiment Station, Ministry of Agriculture, Santiago, Chile.

Ing. Alfredo Mathieu, Director, Southern Experiment Station, Ministry of Agriculture, Temuco, Chile.

Dr. Albert T. Pugsley, Director, Agricultural Research Institute, Wagga, New South Wales, Australia.

Mr. C. M. Driver, Principal Scientific Officer, Department of Scientific and Industrial Research, Christchurch, New Zealand.

Prof. W. Paul Stressmann, Department of Economics, Michigan State University, East Lansing.

Dean Tojib Hadiwidjaja, Faculty of Agriculture, University of Indonesia, Bogor.

Ing. Javier Becerra, Rector, Agrarian University, Lima, Peru.

Dr. Donald Thompson, U.S.D.A. Crop Research Division, North Carolina State College, Raleigh.

Dr. Julia Guzmán, National Center for Agricultural Research, Tibaitatá, Bogotá, Colombia.

Mr. P. M. Chinwuba, Federal Experiment Station, Ibadan, Nigeria.

Dr. D. D. Atmadilaga, University of Indonesia, Bogor.

Mr. Giles E. Dixon, Plant Breeding Station, Department of Agriculture, Ministry of Agriculture, Animal Husbandry, and Water Resources, Njoro, Kenya.

Ing. Manuel Rodríguez Z., Head of the Department of Soil Conservation, Ministry of Agriculture, Santiago, Chile.

OTHER VISITING SCIENTISTS

Mr. G. Edward Nicholson, Special Fund, United Nations; Sir Joseph Hutchinson, Professor of Agriculture, University of Cambridge; Dr. A. Chaparro; and Dr. Carlos Madrid.

Dr. H. M. Beachell, Research Agronomist, U.S.D.A., Beaumont, Texas.

Mr. Thein Tun, I.I.E. fellow and Headmaster at Myittha, Burma.

Dr. Erwin L. LeClerg, Director, Biometrical Services, Agricultural Research Service, U.S.D.A., Washington, D.C.

Dr. Slearm L. Wasuwat, Department of Agriculture, Bangkok, Thailand.

Dr. Gerald O. Mott, Professor of Agronomy, Purdue University, Lafayette, Indiana.

Dr. J. W. Purseglove, Professor of Botany and Dean of the Faculty of Agriculture, University College of the West Indies, St. Augustine, Trinidad.

Dr. Thomas C. Allen, Department of Entomology, University of Wisconsin, Madison.

Ing. Aldo Montaldo, Faculty of Agronomy, Central University of Venezuela, Maracay.

Mr. Juan Esteban Ezcurra, Press Representative and Chief of Public Relations for CAFADE, Buenos Aires, Argentina.

Dr. John Rice, Field Crops Department, North Carolina State College, Raleigh.

Mr. George Platt, Maxwell School of Citizenship and Public Affairs, Syracuse, New York.

Review of the Agricultural Year

Considerable alarm and concern was expressed during the summer of 1960 over the lateness and apparent sparsity of rainfall and the effect that such a condition would have on agriculture in general and on the summer corn and bean crops in particular. A droughty season is a deciding factor in the total annual production of these two crops since approximately 6,000,000 hectares, or 80% of the annual crop area, are seeded under non-irrigable conditions. However, after harvest it was determined that total corn production for the year was approximately 5,500,000 metric tons, down about 450,000 tons from the record 1959 crop. Total bean production was lower by a greater percentage, and the 1960 crop amounted to approximately 400,000 metric tons.

The situation for the total grain requirement for the year was brightened considerably by a bumper winter wheat crop of approximately 1,500,000 metric tons. The 1959-1960 crop amounted to 1,100,000 metric tons. One specific factor that accounted for this increase was an intensive campaign promoted by the Ministry of Agriculture for increased production, with a goal of 1,500,000 tons. As regards the gross agricultural product, the situation was improved by this wheat crop and by the summer cotton crop of 1960, which totaled approximately 2,071,000 bales compared with 1,700,000 bales in 1959.

Farmers and ranchers in non-irrigated regions and Gulf Coast grasslands probably suffered most from droughty conditions in the past year. These experiences serve to emphasize the need and timeliness of at least two projects of the National Institute which are receiving maximum attention at the present time. The first aims at the development of corn varieties with the ability to withstand prolonged periods of drought during the normal growing season and still produce a crop of corn. The second of these projects concerns the study of economical silage production and conservation in order to utilize the excess forage production of the summer months for winter consumption. Historically, more forage is produced on native pastures in the tropics than can be consumed at the time, while very rarely is there sufficient feed material during the dry winter months to maintain the livestock population required to satisfy annual market demands. Significant progress has been made toward the accomplishment of goals of both these projects.

SUMMARY OF RESEARCH RESULTS

The progress reviewed in this report corresponds to the September, 1960—August, 1961 crop year.

CORN

Mention has been made of the reduction in the 1960 corn crop resulting from unfavorable climatic conditions. A combination of improvements must be considered to provide greater stability in the national annual supply of corn. Three prime factors which are now receiving increased attention are: (1) provision of adequate storage facilities for temporary surpluses; (2) expansion of production in dependable growing areas; (3) varietal improvement of corns for natural rainfall conditions where least security exists for satisfactory yields. This last factor of a basic agronomic nature may very well be resolved in the immediate future as a result of development of corn varieties combining drought resistance and an ability to resume normal growth after a prolonged period of drought. Crosses of breeding lines carrying these characteristics performed significantly better than varieties now in production during 1960.

A white dent hybrid, H-507, was released and recommended for production in the tropics of Mexico during the past year. This hybrid has shown a yield advantage of about 20% over the previously recommended hybrid H-503 and about 35% over the best open-pollinated native tropical varieties still being grown.

Three-way crosses of high altitude, intermediate, and tropical corn races have resulted in yields considerably higher than those of local varieties. It is strongly suggested that a major advance in corn yields may be made possible through further work with this material.

The early white dent hybrid H-412 was released and recommended for spring planting in the Yaqui Valley of Sonora as a substantial improvement over existing varieties.

Progress is also being made toward supplying the growing national needs for yellow feed corn varieties.

SORGHUM

Investigations of varietal adaptability and yield testing continued in areas considered most promising for development of this crop. Grain-type triple-dwarf material is being selected and tested for the Bajío and Pacific northwest regions. In further studies of hybrid sorghum possibilities, male sterility has been introduced into breeding lines. In view of the practice by farmers of saving their own seed from year to year for planting, hybrid sorghums are not generally recommended because of yield losses in advanced generation crops.

The variety Sumac continues to outperform other forage sorghums in the Bajío. Material from Africa tested at high altitude stations produced seed under the relatively cool conditions there. This suggests the possibility of developing dependable varieties for the extensive high, cool Central Plateau.

WHEAT

The results obtained from research conducted in the past on the various factors influencing wheat production continue to pay big dividends to the Mexican economy. The current recommendations now widely accepted by growers, involving use of improved cultural practices, chemical fertilizers, control of pests, and the use of improved varieties, are all based on these research findings. As these findings are extended each year to a steadily increasing percentage of the area cultivated to this crop, and as more farmers who have complied with only parts of the recommendations in the past, intensify the use of these recommendations, yields per unit of area continue to increase.

It is estimated that the average national yield for the 1960-1961 crop season will reach 1,800 kg./ha.; this yield is approximately 2.5 times the average national yield 10 years ago. This year the best-producing area, the Yaqui Valley in Sonora, harvested on 120,000 hectares an average yield of 3 tons/ha. These yield increases are encouraging, but it is now time to extend the improved practices to production areas where methods are still primitive, and to introduce the culture of wheat to other areas where it is unknown, if production is to keep pace with increased consumption. To attain the latter objective, new varieties with different characteristics will be needed. The research program has been reoriented within the past two years to meet this expanding need.

During the past year four new high-yielding varieties have been distributed from the breeding program. These are Nainari 60, Huamantla Rojo, Penjamo 62, and Pitic 62. The first two are varieties with straw of conventional length. Both, however, and especially Nainari 60, are somewhat more resistant to lodging than Lerma Rojo. These two varieties will be grown on large commercial areas next year.

Penjamo 62 and Pitic 62 are the first two dwarf wheat varieties developed and released by the program. They are very high yielding and much shorter and more resistant to lodging than the current commercial varieties. Seed of these two varieties will be available for limited commercial plantings during the 1961-1962 crop season.

BEANS AND SOYBEANS

In the improvement program of beans and soybeans, emphasis was placed on the study of genetic improvement, bean and soybean diseases, and cultural practices in regard to date and methods of planting and use of fertilizers and herbicides.

In an effort to incorporate the insect and disease resistance observed in the bean types of *Phaseolus coccineus* into the commercial bean varieties, studies are being continued on the incompatibility between the species *P. coccineus* and *P. vulgaris*. Experiments were also conducted in which the single and mass selections made in

1959 were tested for yield and resistance to disease. A group of lines has been selected and will soon replace those bean varieties of the Canario type and others which have become susceptible to the new races of anthracnose.

A breeding program is now under way to combine in one soybean variety earliness and resistance to shattering and lodging. The varieties involved are Lee, Hood, Hill, and Dorman. The research on the pathology of the bean was carried out under field and greenhouse conditions. It was conclusively demonstrated in the Central Plateau that two distinct groups of races are present, one attacking the bean varieties of the Canario type and the other attacking other types. In regard to bacterial diseases, the resistance to "halo" blight was shown to be controlled by two complementary dominant genes and a χ^2 test of the results indicated that the proportion of resistant to susceptible plants was in the ratio of 9:7. Other projects now under way pertain to the identification of bean viruses and testing of the breeding material for resistance to common root rots of the bean. Soybean diseases have been of no importance where this crop is now commercially grown.

To localize areas where disease-free seed can be produced, experiments were conducted at Tepaltzingo, Morelos, and at Jaral del Progreso, Guanajuato. By planting infected seed (anthracnose and bacterial blights) and observing the plants throughout their vegetative period, it was demonstrated that disease-free seed of adapted varieties can be produced in these semitropical regions of Mexico.

POTATOES

The potato section has made several outstanding contributions to Mexican agriculture. In variety trials, new introductions are studied for possible adaptation in Mexico; the variety Alpha was brought in about ten years ago and now is grown on more than 90% of the potato acreage planted in the regions of León, Navidad, and Zamora.

In 1960, over 14,000 tons of certified potato seed were produced in Mexico. This was enough to meet the demands of farmers, and for the first time no potato seed was imported from Europe. This young program, begun in 1957, is directed by the Department of Cultivation and Seeds of the Bureau of Plant Industry, which has on its staff several former members of the potato research group.

The development of nine new blight-resistant potato varieties has brought the cultivation of this important food crop within the reach of the small farmer, who now has a new basic food crop to supplement his corn harvest.

HORTICULTURE

Trials were conducted at the principal experiment stations to test new improved varieties developed in other parts of the world as well as collections of native vegetable varieties. Home garden plots were established at all experiment stations to serve principally as a demonstration of recommended varieties and cultural practices at annual field days.

Broccoli seed and vegetatively propagated material of recommended varieties of asparagus and sweet potatoes were produced and distributed to farmers.

A new tomato variety for the west coast winter production region was introduced and named Culiacán 1. Breeding work has been continued with winter squash, and tomato breeding was given greater emphasis during the past season.

Seed production studies were continued with onions, broccoli, and lettuce, since local firms are now initiating field production on an increasingly large scale.

FORAGE GRASSES AND LEGUMES

Greater emphasis was placed on the evaluation of forage and pasture productivity in terms of animal responses during the past year. On La Campana Experimental Range in Chihuahua, liveweight gains of yearling steers on native range were greatly increased through use of an economical level of protein supplement. Alfombrilla, the toxic range plant, was successfully controlled through the use of Silvex combined with the wetting agent, Dynawet.

In the tropics at the Cotaxtla experiment station, a feeding trial with steers is indicating the need to supplement Merkerón silage with protein for obtaining liveweight gains. Fence construction and cattle water facilities have been completed in the 12 experimental pastures where grazing studies will be initiated this summer. At present, a total of 88 head of cattle are being maintained for experimental purposes with forage at Cotaxtla.

SOIL FERTILITY AND MANAGEMENT

Soil fertility studies were carried out at the El Horno, Santa Elena, Cotaxtla, and CIANO experiment stations, and in cooperation with farmers in the State of Michoacán and in the Valley of Mexico. Most of the studies were made with corn, wheat, and potatoes; some were conducted with cotton, beans, alfalfa, sesame, and sorghum. Soil moisture studies were carried out with wheat at CIANO and with alfalfa at El Horno.

Experiments were conducted in the field and greenhouse to investigate the cause of the low productivity of the soils in parts of the Sierra Tarasca. The pH values of the surface horizons of these soils varied from 5.4 to 6.4 and the organic matter percentages from 6.3 to 13.2. The available phosphorus contents were low, active aluminum contents were high, cation exchange capacities were high, and the saturation percentages with cations were low. Applications of nitrogen, phosphorus, and chicken manure produced large increases in corn and potato yields in the field studies. A combination of chicken manure and phosphorus resulted in corn yields greatly superior to those obtained with the application of chemical fertilizers alone. Calcium, potassium, molybdenum, zinc, copper, and manganese had little or no effect on corn yields.

Corn fertilizer experiments were carried out on private farms at eight locations in the Valley of Mexico. Yields were increased by the application of nitrogen in five experiments, by phosphorus in two, and by potassium in two. At three locations ear corn yields were 5 to 7 tons/ha. on the unfertilized plots, and there were no significant effects of the fertilizers.

A four-year study of the effect of applications of phosphorus and barnyard manure on alfalfa production at El Horno was concluded. The total yield of dry matter during this period was increased from 55.0 to 81.8 tons/ha. with the application of 320 kg. of P_2O_5 per hectare. Each ton of manure increased yields an amount equivalent to 4.2 kg. of P_2O_5 applied in the form of superphosphate.

A study of the association of velvet bean, jack bean, Sesbania, and Crotalaria with corn planted in 92, 138, and 184 cm. rows was carried out at Cotaxtla during

1958-1960. Corn yields were reduced 10% by increasing the distance between rows from 92 to 138 cm. and 21% when the row width was increased to 184 cm. In the crop following the incorporation of the legumes, ear corn yields were increased 0.64, 0.59, and 0.36 tons/ha. by velvet bean, jack bean, and Crotalaria, respectively.

ENTOMOLOGY

The research activities of the entomology section continue to be directed toward obtaining immediate economic insect control measures for the pests of importance to the basic crops in both the field and warehouse. Parallel with this, work is continuing on insect collection and survey, loss evaluation, and biological control, including plant resistance to insects as well as biological and ecological studies.

In the routine insecticide testing trials, various chemical concentrations, formulations, and numbers of applications as well as new materials were evaluated for control of such pests as fall armyworm and neotropical corn stalk borer on corn, Mexican bean beetle on beans, aphids on wheat, barley, and alfalfa, leafhoppers on rice, thrips and salt-marsh caterpillar on soybeans, and finally, thrips on cotton.

The value of an insect collection and continuous survey is clearly demonstrated by two pertinent observations made during the year covered by this report. A new Strepsiptera, *Sogatelenchus mexicanus*, a parasite prevalent on about 60% of the leafhoppers *Sogata cubana* (Crawf.), was found in the area around the Cotaxtla station. This parasite may prove to be of great value in controlling the leafhopper vector of the "hoja blanca" disease of rice. Similarly, adult moths of an alfalfa defoliator, *Leucochlaena hipparis* (Druce), have been regularly captured in the light trap at El Horno. This insect is a potential pest of alfalfa in the high valleys of Mexico.

Results from the chemical control tests clearly demonstrated the importance of insects in reducing crop yields. At CIANO the fall armyworm was responsible for losses of as much as 1 ton of corn per hectare in untreated plots. In the Yaqui Valley, where control of the salt-marsh caterpillar was effective soybean yields were approximately twice as high as in fields where no control was practiced. The role of the spotted alfalfa aphid in reducing yields and stands of alfalfa at CIANO was clearly demonstrated in experimental results obtained this year. Production was increased as much as 5 tons in individual cuttings when chemical control of the aphid was used.

PLANT PATHOLOGY

Deterioration of stored grain, caused by certain fungi, annually results in the loss of hundreds of thousands of tons of grain in storage in Mexico. The principal pathogens causing these losses have been identified. Their control depends largely upon maintaining the grain at a moisture content below 13%, and acting promptly if this condition is not met.

A new corn disease was discovered in some fields in the moist, cool highlands of central Mexico. The head smut of corn remains a threat to certain new hybrids in the Bajío. Sources of resistance in high altitude corns are available.

The damping-off disease of cotton can be at least partially controlled by the application of fungicides to the seed.

Other activities of the plant pathology section include the development of the permanent collection of diseased plants, research on the stunt virus and *Helminthosporium* of corn, late blight and other foliar diseases of the tomato, and basic studies on members of the genus *Phytophthora,* especially *P. infestans.*

POULTRY

During the past year the poultry industry has been faced with increasing costs of production and diminished market prices. The high cost of production is due principally to high overhead, inefficient utilization of labor, poor management, and excessive mortality. With a view toward alleviating feed costs, much of the work of the poultry section has dealt with the evaluation of economic local nutrient sources. The results of feed trials with grain sorghum show that it may be used interchangeably with corn. The work with rice polishings shows that this material, which is a cheap, readily available by-product of the rice industry, may be incorporated to advantage in poultry diets but that certain aspects of its use require further study. It has been found that native barley may be improved by the use of fungal enzyme and that brewer's yeast may be used as a partial substitute for soybean oil meal.

Research dealing with hatchability of chicken eggs at different altitudes shows that fertility and hatchability of eggs is good regardless of the location of production if the eggs are incubated at the same elevation. The utilization of economic diets in conjunction with Ladino pasture for the rearing of turkeys has been shown to be a feasible management practice.

ANIMAL PATHOLOGY

Investigations in the discipline of animal pathology have been expanded from diagnostic activities to studies of certain specific infectious diseases of poultry and into the specialized field of bovine mastitis.

During the course of the year an average of 40.3 cases per month entered the diagnostic laboratory. Six disease entities, heretofore unencountered by the laboratory, were diagnosed. One of these, known as infectious laryngotracheitis of chickens, was upon recognition reported to the federal authorities who immediately began an eradication campaign as a means of combating the epizootic.

Newcastle disease, a contagious virus disease of chickens, remains the most serious problem of the poultryman and major attention has been directed toward investigation of various phases of this disease entity. The most important finding in this respect was that commercial vaccines commonly in use for prevention of Newcastle disease result in an unacceptable level of immunity. An experimental vaccine was produced which, in preliminary experimental trials, has offered 100% protection against challenge with the virulent Mexican field virus strain. The possible commercial application of this vaccine is now in the stage of investigation.

Mastitis, caused principally by the bacterium *Streptococcus agalactiae*, has been shown by a bacteriological survey of milk from the Mexico City milkshed to be a serious problem. Studies designed to determine the applicability under Mexican dairying conditions of well-known and proven programs for the control of this disease are now under way. Included in this study is an economic appraisal of the cost factors involved in the elimination of mastitis from a Mexican dairy.

AGRICULTURAL ECONOMICS

The work in agricultural economics continues to emphasize farm production economics in both the private and *ejidal* sectors, although a small amount of work is under way in agricultural marketing.

A field study of *ejidal* agriculture with individual operation of parcels has been carried out in the Yaqui Valley, Sonora. This group of *ejidatarios* has quite satisfactory land and water resources (18 hectares of irrigated crop land), employed good production techniques in order to obtain high crop yields, and had credit readily available. Yet these farmers received a negative 3,800 peso income for their efforts as managers and laborers. Obviously there are serious problems of organization and management. One of the most serious is the fact that these farmers do not take an active part in their farming business. Only about 10% of the farmer's and his family's time was employed on productive work in the parcel. Over 70% of their time was classified as nonproductive. But this is more than a simple management problem which can be readily solved by the *ejidatarios* directly affected. The limited participation by this group of farmers in their farming businesses is in large part determined by a series of well-established institutional arrangements.

The Tehuacán regional market has been studied in order to get a better understanding of agricultural marketing processes in a tradition-oriented area. A satisfactory knowledge of just how a traditional regional market functions is basic to a careful consideration of the type of services that must be developed as a region leaves behind its traditional patterns of agriculture and begins to respond to the most recent technological developments. The Tehuacán regional market consists of the central plaza in the city of Tehuacán and eight secondary plazas in towns surrounding the city. In addition to these more important centers, there are smaller commercial activities in the villages and in rural areas. It has been found that in the central plaza the volume of sales amounts to little more than 20 pesos per person engaged in merchandising. While it is obvious that a substantial reduction could be made in the number of people involved in the selling process, it is not believed that the excess group cause unduly high costs to consumers or low prices to producers. The marketing channels are direct and simple. There will be no incentive for more efficient merchandising until wages rise generally in the area. Cultural and social forces will also tend to maintain the status quo.

Four other projects were also continued or initiated during the year.

AGRICULTURAL INFORMATION

The prompt diffusion of research results, a practice well-established by the Office of Special Studies, continues to be the policy of the new National Institute of Agricultural Research.

In the line of farmers' bulletins, greater emphasis has been given to the publication of specific recommendations for the different regions of the country. The regional circular series have been augmented with five numbers from El Horno, three from La Campana, four from CIANO, and two from Cotaxtla. In addition, six new manuscripts by staff members of the Institute were published in the bulletin series of the federal Extension Service and 12 earlier bulletins were reprinted. More than 100,000 copies of these publications were distributed by extension agents.

The new technical publications include the following: two numbers of *Agricultura Técnica en México* with 35 articles, six new *Folletos Técnicos*, one *Folleto Misceláneo*, and the Spanish edition of the annual report.

Seven articles on horticultural crops and a double volume on the control of insects and diseases were distributed to horticulturists through the quarterly *Novedades Hortícolas*.

All of the farm magazines and national newspapers as well as many regional and local papers regularly use information from the National Institute, thereby giving a broad distribution to research results and recommendations. The farmers' bulletins also provide the information for many radio programs, among them the *Voces del Campo* series broadcast by extension agents in most of the states of the Republic.

Three more 16mm movies are nearing completion, making a total of 16 in this series. These films are providing strong support for extension agents and other agronomists in promoting the adoption of new varieties and improved farming practices. It is calculated that some 500,000 farmers have seen at least one of these films during the past four years.

The attendance at experiment station field days increased again this year, with the result that some 6,500 farmers and cattlemen became personally acquainted with the experimental work.

Several research projects have been initiated in the communications field. These studies are already providing a basis for improvement of the section's informational activities and should eventually make an important contribution to the general body of knowledge related to the problems of communicating ideas and gaining acceptance of improved farming practices.

LIBRARY

Use of library facilities during the period covered by this report nearly doubled in comparison with the previous year. A good deal of this increase is due directly to the reorganization of the agricultural research programs. Development of research center branch libraries proceeds satisfactorily in an effort to bring the library to investigators located so far from the central facilities as to make regular visits impractical. Over 1,000 acquisitions were added to the library during the past year. The technical maintenance and availability of current agricultural information is indispensable to the satisfactory development of research projects. It is apparent that the library is filling a vital and constantly growing need in the fields of agricultural research and training.

Comparative yield trial on a farmer's field.

Corn

Total corn production in Mexico in 1960 fell considerably below the record harvest of 1959, owing principally to a serious drought that affected large areas of the States of Durango, Coahuila, Chihuahua, Querétaro, Guanajuato, Aguascalientes, Zacatecas, and Sinaloa and parts of other states. Although normal or better yields were obtained in the sections of the country where rainfall was adequate, these were not sufficient to offset the drought losses in total production.

The wide fluctuations in annual production of corn under the highly undependable rainfall pattern of most of Mexico point up the need for stabilizing influences on the available supply of corn. One such would be adequate storage facilities for temporary surpluses; expansion of production in dependable growing areas is another. Sections of the northwest coastal area seem to offer particular promise of providing greater production under satisfactory irrigated conditions. Not only, however, must national production be raised to a level where it can keep pace with the growing population; until there is an excess available, corn cannot be used to any large extent as a feed grain for animals. The solution to the problem thus involves not only improved varieties and cultural practices, but improved systems of marketing and storage as well. Much also remains to be done in translating experimental research results into accepted practices on the farm.

The principal effort of the corn section has been devoted to the development of improved varieties and hybrids. In Mexico, as in many other parts of the world, improved varieties seem to offer the most practical solution to a great many specific problems of insect and disease control, as well as the means of securing greater yield potential. Repeated trials of introduced corns, such as U. S. hybrids, have verified the early observations that locally developed varieties from native materials are essential if serious difficulties arising from the use of non-adapted germ plasm are to be avoided. The great wealth of variability in the native corns not only provides adequate material for the breeding programs in Mexico, but is also proving to be of great value in other countries. As the need for more fundamental information in order to make the next steps of improvement becomes increasingly evident, greater emphasis is being put on basic studies of the native corns.

The present improvement program serves four different ecological areas, represented by the Cotaxtla, El Roque, CIANO, and El Horno experiment stations. Improved corns are in commercial production in each of these areas. Breeding programs are oriented toward further improvement of the presently recommended varieties and the development of certain special corns, such as yellow feed corn and short-season types. The more specific objectives of these programs, together with the results obtained at the four stations in 1960, are reported below.

COTAXTLA

DESCRIPTION OF PROGRAM

Roughly half the tropical area of Mexico can be considered as having sharply defined wet-dry cycles during the year, with rain falling during the summer months; the other half has less sharply defined cycles and receives some winter rainfall. Corn is a major crop in both areas.

Yield testing of corns for these two general climatic divisions is conducted in winter plantings at San Rafael, Veracruz, and in summer plantings at Cotaxtla. Almost all of the controlled pollination work is done at Cotaxtla, where winter irrigation is utilized to achieve two cycles per year.

Specific characters involved in the improvement of the recommended hybrids are reduced height; resistance to corn stunt; resistance to *Helminthosporium;* resistance to insect attack; better shuck cover; and higher yield.

RESULTS IN 1960

During 1960 the tropical, white dent hybrid H-507 was released and recommended for production. Seed of the lines and crosses involved were turned over to the National Corn Commission; 750 samples of about 2 lbs. each were distributed to farmers during the station field day for trial on many farms. H-507 has shown a yield advantage of about 20% over the previously recommended hybrid (H-503) and about 35% over the best open-pollinated native varieties in the area.

Experimental hybrid combinations of yellow lines were tested in an effort to develop a yellow corn to meet the growing demand from feed producers. Additional yellow synthetics were also formed at Cotaxtla and tested in the States of Veracruz, México, Guanajuato, and Sonora. Outstanding yields were obtained in both Sonora and México from certain synthetics, and it appears that yellow corns are now available to meet current demands in the tropics of Mexico.

The isolation of resistance to the corn stunt virus and the study of its breeding behavior is being intensified. Several lines that appear very resistant have now been isolated from collections from Cuba, the Dominican Republic, and Honduras, and additional lines showing resistance have been obtained from several Mexican collections. One observational field planting of these same lines in El Salvador gave results identical with those in Veracruz, an indication that the virus is behaving similarly in both countries with respect to the corn genotypes tested. In cooperative work with the entomology and plant pathology sections, artificial inoculations using caged insects are under way to obtain more precise classification of lines and crosses.

Studies of synthetic-variety formation were continued. In one study, combinations of 4, 6, 8, etc. to 24 lines were compared over 3 generations; the combinations of 8, 10, and 12 lines gave the highest yields. Other studies include comparisons of visual selection, plant-to-plant crosses, and topcross testing. At least one synthetic will be increased and tested on farmers' fields during 1961 for possible release as a variety. Synthetics are needed both for farmers who do not buy hybrid seed each year and for areas where the hybrids developed so far do not quite fit. In such areas, good synthetics may be more useful since their variability will enable the farmers themselves to select for local conditions.

Germ plasm pools of the highest-yielding combination of races resulting from previous studies (see 1959-1960 report) were formed. These pools will be used not only in the breeding program at Cotaxtla but also at other stations and in widespread observational plantings with farmers to evaluate possible new zones of utilization for this germ plasm.

Progress was made in the search for both earlier maturing tropical corns and for shorter plant height. Segregations from racial crosses have resulted in many promising lines. Preliminary hybrid combinations of both kinds will be made in 1961.

During 1960 the first tropical dwarf hybrid (brachytic 2) was tested. Plant height (about 6 to 6½ feet) and ear height (3 feet) were very acceptable, and yields were sufficiently promising to warrant further testing.

Combinations using male sterility for hybrid formation were further tested. "Male-sterile vestigial glume" and "male-sterile Reid's source" are highly variable in expression in Mexican corns and considered of little value, at least thus far, for commercial production requirements. "CME × Kys" and "Texas source" male sterile appear more stable. At least one tropical double cross now appears ready for large-scale testing.

In various degrees of development are more basic studies, including Design I in the race Tuxpeño, mass selection, modified reciprocal recurrent selection, random line development, separation of the race Tuxpeño into its supposed ancestral types (Tepecintle and Clotillo) and recombination, and diallel variety crosses within the race Tuxpeño. These studies are being carried out jointly with the Inter-American Maize Improvement Project.

El Roque (Bajio)

DESCRIPTION OF PROGRAM

This important agricultural zone of intermediate altitude requires two distinctly different types of corn: (1) relatively long-season varieties suitable for production under irrigation, and (2) drought-resistant short-season varieties for natural rainfall conditions. Two special problems that have developed in recent years are the need for varieties resistant to head smut (*Sphacelotheca reiliana*) and a demand for yellow corns of good color for use in poultry and other animal feeds.

RESULTS IN 1960

Because of the extended growing season under irrigation and the wide choice of crops, date-of-planting yield tests were initiated to determine the date that would most efficiently utilize available crop-sequence possibilities. Highest yields were obtained from the April 1 date of planting. However, as shown in Table 1, all dates were satisfactory from a yield standpoint, and each might be fitted into rotations with the other important crops.

TABLE 1.

Average yield per hectare and percentage of tassel smut infection of 12 corns grown in date-of-planting trials. Cortazar, 1960.

	DATE OF PLANTING							
	Mar. 1	Mar. 15	Apr. 1	Apr. 15	May 1	May 15	June 1	June 15
Yield[a]	5,855	5,940	6,340	5,720	5,820	5,550	5,140	4,235
% smut	9.9	11.8	16.1	18.6	20.7	19.9	21.4	23.2

[a] Kg./ha. of shelled corn at 15.5% moisture.

The data in Table 1 concerning smut infection again emphasize the importance of finding out more regarding the specific optima for infection by this fungus. As measured by dates of planting, the highest percentage of infection occurred in late plantings in 1958, in early plantings in 1959, and in late plantings in 1960. Date of planting by itself obviously cannot be used as a means of avoiding losses from this disease. While inoculum is known to exist throughout the zone, serious losses have been restricted primarily to a single area near Cortazar, Guanajuato, and individual fields elsewhere. Although the reasons for this remain unknown, it is not a case of susceptible versus resistant varieties. Relatively resistant material has now been isolated over a period of three years, using heavy artificial inoculation of seed.

Following up the study of tropical × high altitude corn combinations that produced high yields in the Bajío in 1959, hybrid combinations were made in an attempt to exploit these results for commercial use. Data summarizing the outstanding comparisons are shown in Table 2. While these are for one year only, there appears real promise of a major advance in irrigated corn yields for this region in a short time.

Although these materials were grown under conditions of heavy smut infection, the differences between the new combinations and the recommended hybrids are still substantial after adjustment for smut losses. (The loss is equal to the percentage of infection since no grain is produced on infected plants.) The freedom from smut shown by the new hybrids was largely unexpected and may have been due to escapes rather than to resistance. These hybrids are three-way crosses among the races Chalqueño (high altitude), Celaya (Bajío), and Tuxpeño (tropical).

Hybrids of the tropical series (H-501, H-503, etc.) have been included for observation in the Bajío program and usually produce very high yields. They are extremely long-season corns, however, and require excellent care in the use of fertilizer and water. Possible disease and insect attack under these different conditions, added to their special requirements, have prevented them from being recommended. At least one large commercial planting of H-503 produced an outstanding yield in 1960, but because of the known problems associated with its production, H-503 will not be recommended for this area.

No new varietal recommendations for natural rainfall plantings were made in 1960.

TABLE 2.

Yield and agronomic data of three-way hybrid crosses planted with irrigation. Cortazar, 1960.

Hybrid	YIELD		RATINGS[b]		
	Kg./ha[a]	% of H-309	Ear	Plant	% Smut[c]
{Ch.II-148-2-2-1 × Hgo. 4-5-4-2-1} × H-353-62	9,550	165	1.1	1.6	4.3
“ × -24	8,980	155	1.6	1.3	1.3
“ × -50	8,810	152	2.0	2.0	1.5
“ × -26	8,470	147	1.6	1.9	0.7
“ × -49	8,180	142	2.3	1.9	0.0
H-309	5,780	100	2.1	2.1	18.1
H-352	5,720	99	1.9	1.9	19.0
H-353	3,660	63	1.9	2.4	43.5

[a] Shelled corn at 15.5% moisture.

[b] Scale of 1 = good, 5 = poor.

[c] *Sphacelotheca reiliana.*

Several experimental crosses, involving both inbred materials and varieties, gave promising results. Racial intercrosses again are among some of the best. The special character "latente" (see section on El Horno) was crossed to a series of materials for testing in 1961. Collection of data comparing corn with sorghum as a possible recommended substitute crop for drier areas was continued. In three of the last five years, including 1960, substantial portions of the natural rainfall corn-producing areas of the Bajío have had virtual crop failures owing to lack of rain. In these and other marginal dry corn areas, sorghum would appear to be a better crop.

Demand for yellow corn for use in animal feeds is heavier in this area than in any other part of the country. Local feed producers are unable to secure the amounts they now need. Improved yellow varieties will not be ready for release until at least one more year of trials. By the end of 1961, however, it is expected that at least a provisional release and recommendation will be made.

CIANO

DESCRIPTION OF PROGRAM

While corn production still is far from reaching its full potential in the northwestern coastal region of Mexico, interest is increasing. Various factors are contributing to this: the region's physical assets of favorable soil, water, and climatic conditions; the national need for more corn; and the local need for greater diversification of crops. The two major crops of wheat and cotton leave a large gap in the year when corn can be grown without disrupting the wheat-cotton sequence. Wheat is planted in late fall, November and December, and harvested in spring; cotton is planted in March and harvested in mid- to late summer. Following the May wheat harvest, corn can be planted in late August and harvested in late January or February, well before cotton planting in March. Corn may also be planted in March for midsummer harvest, as an added diversification.

RESULTS IN 1960

The early white dent hybrid H-412 has been released and recommended for spring planting in the Yaqui Valley (Table 3). It is an interim release and fills the need for an early variety that will flower and escape the high temperatures of early summer. It may also be used to extend, to some degree, the late summer planting period for which the later hybrids are recommended.

TABLE 3.

Comparison of predicted and actual yields of H-412. CIANO, 1960.

	Predicted yield[a]		Actual yield (1960)	
	Kg./ha.[b]	% of V-401	Kg./ha.	% of V-401
H-412	5,271	129	5,715	123
V-401	4,075	100	4,642	100

[a] Based on 1958-1959 single-cross data.
[b] Shelled grain at 15.5% moisture.

Local demand for yellow corns has also developed in the area. One unnamed hybrid can now be recommended to fill this need, and several synthetics from the combinations of germ plasms formed at the Cotaxtla station appear well adapted. As demand grows for yellow corns, these can be developed further for this area, but the urgent immediate needs for a variety that can be recommended have now been met.

EL HORNO

DESCRIPTION OF PROGRAM

The mountainous central part of Mexico is extremely variable in elevation and in available moisture. Because corn is widely grown throughout the area under both irrigated and natural rainfall conditions, the improvement program has been divided into three elevation levels represented by El Mexe, Hidalgo (1,900-2,100 meters), El Horno (2,000-2,400

New hybrid H-412 in large-scale plot tests prior to release, CIANO.

meters), and Santa Elena (above 2,400 meters). A further general division has been made between late corns for irrigated conditions and early, drought-resistant corns for natural rainfall conditions. No program can hope to fulfill all the special situations that exist in the many subclimates, but excellent improved corns are now available for all major irrigated areas. Substantial use is also being made of these corns for silage production in the Valley of Mexico.

Extremes of rainfall, intensity of sunlight and cloud cover, soils, and other factors combine to make natural rainfall corn production a complex problem. Efforts are directed at getting the largest possible return for the time and money invested through concentration on the larger areas of production.

RESULTS IN 1960

An extensive off-station testing program was begun in 1960 and will be continued in 1961. Nearly 30 yield trials were grown at various locations on private farms over a wide area of the central plateau and mountain region. These trials should give a more complete orientation to the breeding program as to the types of corn needed in the various areas. It appears, for example, that corns developed primarily for irrigated plantings near El Horno may do well under natural rainfall conditions in parts of Puebla. Several experimental hybrids looked very promising in these trials and may well extend the areas for which improved corns are available.

Hybrid combinations of the races Tuxpeño, Celaya, and Chalqueño were again the highest-yielding materials in the El Mexe trials.

In anticipation of the coming demand for yellow corns in animal feeds in the area, a program was initiated to develop suitable yellow varieties. Several methods have been utilized, not only at El Horno but throughout the program, to make improved yellow corns available. Although yellow native varieties have been collected and tested, thus far the better-yielding materials have come as the result either of combining introduced and local materials or of converting white varieties to yellow by means of crossing to a good yellow-colored variety and then backcrossing to the white.

Cuban yellow has been most utilized as a color source in the program at El Horno. Preliminary combinations of recovered lines were selected in 1960 to be tested further in 1961. Provisional hybrids are now formed and could be released if the need appeared urgent.

In the improvement of corns for natural rainfall conditions, emphasis was put on the specific drought-resistance character that has been called "latente." This latent character apparently acts to decrease sharply the plant's rate of development under severe moisture stress conditions. Selected in the extreme drought year of 1957, this character discovered in the collection Mich. 21 has been subjected to a series of evaluation trials. The data obtained thus far indicate that (1) several lines from Mich. 21 demonstrate excellent drought-resistance in the usual sense; (2) these lines largely cease development when subjected to drought conditions about 45 days after planting (before tasseling starts, but when plants are of good size); and (3) combining ability of these lines is good (Table 4). The "latent" quality has its value in that the plant resumes normal growth when moisture is supplied. A differential of over two weeks in relative flowering dates has been obtained by subjecting "latente" and normal corns to drought conditions in the field. In further studies, an attempt is being made to follow the character in crosses to see whether it can be transferred to other lines.

As can be seen in the comparison of yields in Table 4, this character appears to offer immediate possibilities for use in the natural rainfall area with conditions comparable to those at El Horno. In addition, "latente" has been crossed to all the lines and varieties in other natural rainfall breeding programs in the Bajío and to a series of other materials as well. It is still too early to estimate its possible value in such combinations.

The drought-resistance character "latente" enabled corn on the right to resume growth on moisture supplied by hail.

TABLE 4.

Yield and agronomic data of crosses of "latente" with other materials. El Horno, 1960.

Cross	Yield in % of tester	Ratings[a]	
		Ear	Plant
Mich. 21 Comp. 1–7–2 × Mich. 21–2	178	1.6	2.6
[Mich. 21 Comp. 1–7–2 × (Mex. 39 × Mich. 21–20–29–2)] × ♀H–24	170	2.2	2.0
Mich. 21 Comp. 1–7–2 × (Mex. 39 × Mich. 21–20–29–2)	166	3.0	3.9
(Mich. 21–2 × Mich. 21 Comp. 1–7–2) × (Mich. 21–181–4–3 × Mich. 21–101–2–1)	160	2.0	2.5
♀H–24 × LI–III–Comp. I	150	2.0	3.0
♀H–24 × Mich. 21 Comp. 1–7–2	138	2.4	2.9
♀H–24 × Mich. 21 Comp. 1–104	131	1.7	2.2
Tester (average of H–24, VS–102–E, and local open-pollinated variety)	100	3.3	3.3

[a] Scale of 1 = good, 5 = poor.

Harvesting a forage sorghum yield trial at CIANO.

Sorghum

Drought, large supplies of sorghum from the previous year, and a record corn crop in 1959 all combined to reduce somewhat the production of grain sorghum in 1960. Rough estimates place the acreage at 90,000 hectares and production at 200,000 metric tons, in contrast to 105,000 hectares and 230,000 tons in 1959. This reduction has proved unfortunate; supplies did not keep pace with the growing demand for sorghum and prices were forced upward. A sharp increase in production is in prospect for 1961.

The nature of much of the natural rainfall farming areas of Mexico is such as to favor the increased use of sorghum as a cereal. Of the grains, it is probably the best suited to the highly variable and inadequate rainfall conditions prevailing in most of the country. Drought and heat are usual, and sorghum withstands both more satisfactorily than do the other cereals.

The sorghum improvement program continues to be one of cautious expansion. Observational and test plantings are being continued, in cooperation with farmers, schools, extension agents, and various agencies, to determine areas of adaptation of different types of germ plasm and to define the major problems in each region. For most areas varietal recommendations are now substantiated by at least three years' comparative yield data.

Because the introduced varieties (largely from the United States) do not in all cases provide the needed characteristics, the breeding work is aimed at filling these gaps. Specifically, earlier varieties are needed in many areas, and varieties better able to set seed dependably at elevations above 1,800 meters would mean tremendous production possibilities. Hybrids developed in the United States generally do not maintain their relative yield advantage over open-pollinated varieties when grown in Mexico. It appears, however, that locally developed hybrids will give yields comparable to those achieved in the United States.

In order to expand the variability of the available germ plasm, additional collections of native materials are being brought in from Africa and other parts of the world, principally in a search for collections from high mountain areas and types that might be especially suited for certain definite uses other than as a general feed grain.

Damage from birds continues to be a major problem in many areas and is a limiting factor in some places. Damage is especially severe in small plantings and where no suitable alternative food is readily available to the birds. No practical solution has been found.

GRAIN SORGHUMS

Breeding work involving crossing and selection is centered in the Bajío area near Cortazar, with principal yield testing also carried on there and at CIANO.

A large series of experimental hybrid combinations was grown in observational plantings for elimination of those with unacceptable agronomic characteristics. Those considered acceptable will be yield tested in 1961.

A large number of quadruple dwarf lines have been developed from the sorghums best adapted to Mexican conditions. Quite a few of the best of these have now been converted to male-sterile lines, and at the same time "A" and "B" lines from these materials have been separated and classified. Quadruple dwarf hybrids are now possible, but the intent is to select the tall mutants from these populations in order to form stable triple dwarfs. In general, the quadruple dwarfs are extremely short and therefore not acceptable from an agronomic standpoint. Several populations of previous crosses with exotic germ plasms (largely from India) converted to quadruple dwarf were grown in 1960 and the taller mutants selected.

Male sterility has also been introduced into a series of forage sorghums and broomcorns to facilitate crosses in these types.

Yellow endosperm sorghums were further selected for agronomic characters and will be put in yield trial in 1961 for possible preliminary selection and release of the best. Emphasis on this phase of the breeding work may be altered, depending on the results of animal feeding trials (see Poultry report).

BAJIO

The use of hybrid sorghum carries with it the problem of farmers' planting the second generation seed. In order to obtain more precise data on the yield loss to be expected from this practice, five of the Texas hybrids were compared in yield trial for the second year under Bajío conditions. The drop in yield between the F_1 and F_2 was even more pronounced than in 1959 and indicates the need for education of farmers on this point if hybrids are to be recommended and used. Thus far, only Texas 660 has shown any real yield advantage over Kafir 60 for grain production in the Bajío.

Although drought reduced yields appreciably in 1960, the relative advantage of sorghum over corn in this respect was clearly evident. In continuing the study of the performance of corn vs. sorghum in the Bajío area under natural rainfall, it would seem desirable to emphasize the economic return and the reliability of harvest of sorghum over a period of several years, to afford a reasonable comparison. In many cases in 1960, the comparison was between a fair harvest of sorghum and nothing for corn.

CIANO

On the basis of yield trials in 1960 and previous years plus the added factor of seed availability, the grain sorghum varieties Texas 610, Texas 620, Amak R-10, Amak R-12, NK-135, and C. Hegari I are being continued on the recommended list for the Yaqui Valley. Other varieties that do as well or better will also be recommended when seed supplies are available.

For the present at least, it appears that in this irrigated area corn offers better possibilities of economic return than does sorghum. Accordingly, sorghum production is not being emphasized except in regard to local needs and such demand as may develop. Farther south along the Pacific Coast, in the State of Sinaloa, real need does exist for greatly expanded work on sorghum, and it is planned to initiate trials near Culiacán in early 1961.

EL HORNO

Three promising sorghum introductions from Africa, bearing the names Magune, Wyundo, and Mabere, produced full sets of seed at El Horno in 1960, whereas the check variety Early Hegari set no seed. These collections also set some seed at Santa Elena, an indication that they are able to reproduce under relatively low temperatures. They will be tested extensively in observational plots on farms throughout the high central mesa area in 1961. They will also be crossed to early dwarf types in order to begin development of combine grain varieties should they prove suitable for the high, cool, central plateau, for which there is so far no dependable grain variety.

FORAGE SORGHUMS

Forage yields also were decidedly lower because of drought. It is interesting to note, however, that in spite of the completely different moisture conditions in 1960, the variety Sumac was again the highest yielding, as it was during the previous four years.

A commercial increase field of Nainari 60, Yaqui Valley.

Wheat

Unusually favorable climatological conditions prevailed throughout the important wheat-producing regions of the country during the 1960-1961 cycle, and it is estimated that upon completion of the harvest a new national record of approximately 1,800 kg./ha. will have been established. In most of the major wheat-growing areas, yields of 2.5 tons/ha. or more are common. Many farmers are harvesting 3.5 tons, and an occasional one has obtained yields of over 5 tons. At the same time, yields of less than 2 tons/ha. are rare.

Roughly 830,000 hectares were planted to wheat during this cycle (compared with 750,000 hectares in 1959-1960), and it is expected that a crop of over 1,500,000 tons will be obtained. This will be sufficient to meet the demands of local consumption and will probably leave a small surplus—less than 100,000 tons—that will be in no way detrimental to the country's economy, since national consumption is increasing at the rate of some 60,000 to 70,000 tons annually.

Although the new yield record was attained largely owing to favorable climatic conditions, other contributing factors were an expansion in the area under fertilization and improved land preparation and irrigation practices on a greater number of farms, as well as the ever-increasing use of newer improved varieties. Currently, about 98% of the annual wheat harvest is derived from improved wheat varieties.

Through the distribution of the new, high-yielding varieties Nainari 60, Huamantla Rojo, and Santa Elena, which were in limited commercial production for the first time this year, it will be possible to increase the average national yields considerably more, and the still newer, semi-commercial dwarf varieties, i.e., Penjamo 62 and Pitic 62, promise to be even better.

As in previous years, from 80% to 85% of the wheat acreage in this cycle was planted to the soft wheat Lerma Rojo, which outyields all other varieties. The extreme popularity of Lerma Rojo has tended to drive out of production the lower-yielding, hard wheats (Yaqui 54, Chapingo 53 and 52, etc.) which are necessary for use in certain types of flours. Since there is no difference in market value between the different types of wheat, this situation will not be corrected until a dwarf variety is distributed that possesses the strong gluten of Yaqui 54 and is also capable of outyielding the soft wheats Lerma Rojo, Nainari 60, Huamantla Rojo, and Santa Elena.

REGIONAL PRODUCTION

NORTHWEST

This is the most important wheat-producing region of the Republic. It is estimated that in the States of Sonora, Sinaloa, and Baja California approximately 335,000 hectares were planted to wheat. Considerably more than half the national production will come from this area. Average yields will approximate 2,500 kg./ha., or nearly 300 kg./ha. above the previous record. In the Yaqui Valley, the best wheat-producing area in Mexico, yields will average about 3,000 kg./ha. on an area of 120,000 hectares.

In contrast to the situation in many past years, high temperatures did not occur during the time the wheat was flowering or when the grain was in the early stage of development. This resulted in the production of grain of extremely high test weight and was at least one of the factors contributing to high yield. These same diurnal temperatures, however, also resulted in a greater than normal amount of "black point," a black discoloration on the germ end of the grain. In Mexico, this condition is invariably caused by *Alternaria*. The discoloration is of little importance since it is confined to the outer layers of the bran and is automatically removed during milling.

During the time of the last irrigations strong winds considerably increased the amount of lodging in most wheat fields. Lodging has been increasing along with the more intensive use of fertilizers and with improved planting methods, but may be greatly reduced, and perhaps eliminated entirely, through the use of new dwarf varieties with shorter and stronger straw.

Varietal Performance

Lerma Rojo again constituted about 85% of the area dedicated to wheat in the Northwest. It continues to be resistant to all of the prevalent races of stem rust. Although susceptible to the prevalent races of leaf rust, it nevertheless outyields other commercially available varieties, some of which are resistant to this disease.

Yaqui 54 and Yaqui 54A occupied second place in the Northwest. Both continue to be resistant to the prevalent races of stem rust. The remaining 5% to 10% of the wheat production is represented by Gabo 55 and 56, Yaqui 50, Toluca 53, Yaktana, Barrigón, Lagunero 58, Ramona 44, and Constitution 1088, as well as several new varieties grown commercially for the first time in this cycle.

The new variety Nainari 60, which is the result of the multiple cross [(Supremo-Mentana × Gabo) (Thatcher-Querétaro × Kenya-Mentana)] × Gabo, is particularly well adapted to the Northwest region. It is high-yielding and resistant to the common races of stem rust, moderately resistant to leaf rust, but susceptible to stripe rust; this last characteristic makes it unsuitable for planting in the high valleys of Mexico. Nainari 60 has considerably stronger and shorter straw than Lerma Rojo and since it is, furthermore, the only wheat that has consistently outyielded Lerma Rojo in experimental plantings over the past four years, it will achieve a rapid distribution in this region. It is estimated that approximately 40,000 hectares of Nainari 60 will be planted during the coming season.

Penjamo 62 and Pitic 62, the first two dwarf wheat varieties to be released for commercial production, are derived from crosses involving genes obtained indirectly from the Japanese variety Norin 10. During the past season, these two varieties were grown in multiplication fields on several farms, with outstanding success. Both will outyield all other commercial varieties, including Nainari 60. They possess adequate resistance to stem and stripe rust and are widely adapted, but will be of special value in areas such as the Northwest where lodging is currently very severe. Limited quantities of seed of these two varieties will be available next cycle.

Pests and Diseases

Damage from field rats and the English grain aphid was not commercially significant during the current season.

Stem rust has virtually disappeared from the region in the past five years. In this cycle the entire area, with few exceptions, was planted to improved varieties that are resistant to the prevalent races of this pathogen.

Climatic conditions were generally unfavorable to the development of leaf rust, and there was virtually no reduction in yield from this disease. The severity of infection was in all instances much lower than in most recent years.

BAJIO

It is estimated that in this region, also, yields set a new record. The average yield for the Bajío will probably reach a figure above 2,300 kg./ha., or 500 kg./ha. more than in the previous cycle.

Judging from the general aspect of the crops, about 85% of the farmers in this region now fertilize their wheat. With the exception of some isolated zones in Jalisco and Michoacán, land preparation methods and planting and irrigation practices have improved greatly in recent years.

Extensive lodging was encountered for the first time during the current cycle. The problem is much less severe, however, than in the Northwest.

Varietal Performance

Because of its superior yielding capacity, Lerma Rojo still constitutes more than 90% of the area planted to wheat in the Bajío.

The acreage planted to Chapingo 53 was considerably reduced during the current cycle; this hard-textured variety is now grown on a large scale only in the State of Aguascalientes, where it continues to represent over 60% of the production. Gabo 56 has all but disappeared owing to a prejudice against its white grain color on the part of a small group of local millers.

The two new dwarf varieties, Penjamo 62 and Pitic 62, are being multiplied for distribution in the Bajío. During the current cycle, multiplication fields of Pitic attained a yield of 4.5 tons.

Excellent durum dwarf wheat varieties have now been developed.

Pests and Diseases

Although no losses were suffered from field rats this season, the English grain aphid (*Macrosiphum granarium* Kirby) continues to cause serious damage when recommendations for control are not followed. It is estimated that the total harvest of the Bajío will be reduced 12-15% because of this insect.

There was virtually no stem or leaf rust anywhere in the region this year.

HIGH VALLEYS OF CENTRAL AND NORTHERN MEXICO

In general, climatic conditions were ideal for obtaining a good harvest in this heterogeneous region. The area devoted to summer plantings in the Sierra de Arteaga was the only one affected by drought. In the other areas, yields were remarkably good, and a level of almost 2,000 kg./ha. was attained in the States of Puebla and Tlaxcala.

Varietal Performance

In the summer (1960) cycle in Puebla and Tlaxcala, Lerma Rojo still constituted a high percentage of the area in commercial plantings. There is a growing tendency, however, to replace it with Andes. Although Lerma Rojo continues to be resistant to the stem-rust races prevalent in the summer wheat regions, its susceptibility to leaf rust has decreased its popularity among farmers, even though the effect of this disease on grain yield is difficult to measure.

Andes is now the second most important and popular variety in the high valleys of Puebla and Tlaxcala. It is highly resistant to the prevalent races of stem, leaf, and stripe rust and yields slightly more than Lerma Rojo in summer; the latter, however, is superior in winter.

The best-performing new varieties for the high valleys are Huamantla Rojo, Santa Elena, and the dwarf wheat Pitic 62. Commercial acreages were planted with these three in the summer of 1960 in zones that included Puebla, Tlaxcala, Hidalgo, and México. Huamantla Rojo performed the best and it will be widely distributed among farmers during the summer of 1961. Santa Elena, with similar disease resistance characteristics and yielding substantially the same, has shorter and stronger straw. Huamantla Rojo has stronger gluten than either Santa Elena or Lerma Rojo.

Pests and Diseases

Summer wheat production has never been seriously affected by animal pests or insects. Weed control, however, is of vital importance in this type of culture; without proper use of herbicides, yields are greatly reduced.

Leaf rust appeared in all fields planted to Lerma Rojo, but yields were good and it was impossible to estimate losses caused by this disease. All plantings remained free of stem rust.

Commercial multiplication of Toluca 1, Bajío.

Barley

Even though the barley improvement program in Mexico is relatively new, it has made concrete contributions toward increasing barley production and improving quality.

Until three years ago, virtually all of the domestic barley production, some 250,000 hectares, was grown in the high valleys of central Mexico during the rainy season. Because the common barley grown was a mixture of many types and primitive cultural practices were used, both grain yields and grain quality were poor. At that time, a large percentage of the malting barley was imported.

It was obvious that to change production in the high valleys would be a slow, lengthy process, although to do so remained a primary objective. A more immediate solution to the malting barley problem was to convert part of the irrigated land no longer needed for wheat production in Sonora and the Bajío to irrigated winter barley production.

On the basis of varietal tests, Vantage, an introduction from Canada, and Atlas 54, from California, were selected as the two best candidates with which to establish irrigated production in Sonora. Although these two varieties are much less desirable for malting than is Toluca 1, an excellent variety, they can be grown successfully under Sonora conditions where both shattering and lodging are primary considerations. The introduction of irrigated barley production in Sonora has been very successful and has expanded rapidly. During the current season approximately 20,000 hectares were planted, from which a crop of 50,000 tons was harvested. With modern additives and malting techniques, this grain is serving a very useful purpose.

Simultaneously with the introduction of irrigated barley production in Sonora, a like effort was undertaken in the Bajío. Since the problem of shattering is somewhat less here than in Sonora, it was decided to build production on the variety Toluca 1. In the first two years, results were rather discouraging because of inadequate fertilization. During the current season, however, an area of 5,500 hectares was planted, from which a crop of 15,000 tons of excellent grain of outstanding malting quality was obtained.

The establishment of irrigated barley culture has now made it unnecessary to import malting barley. Slow improvement is also being made in the culture of barley under summer rainfall conditions in the high valleys. Yields are increasing, and in some cases grain quality is improving. The improved varieties, Toluca 1 and Vantage, are gradually replacing the native mixed varieties. Many farmers are beginning to fertilize their barley and to control weeds with chemical weed killers. In general, barley is beginning to be treated as a "respectable crop" on many of these farms, instead of as a crop for planting on worn-out soil where nothing else will grow.

A large number of promising, advanced generation lines from the breeding program are now ready for yield and quality testing.

Increase blocks of the variety Bayomex at Chapingo.

Beans and Soybeans

The bean improvement program has as its aim increased production per unit area of land. To achieve this end, research has been conducted on (a) bacterial, fungal, and viral diseases, (b) genetic improvement, including a study of the interrelation and compatibility of the species of *Phaseolus*, and (c) farm practices with respect to date and methods of planting and use of fertilizers and herbicides.

Complementary studies related to bean production are conducted in cooperation with other sections of the National Institute and with the National Corn Commission.

BEAN BREEDING AND IMPROVEMENT

BEAN DISEASES

During the past year, research on the pathology of beans was largely carried out under laboratory and greenhouse conditions at El Horno, with emphasis on identification of physiologic races of rust and anthracnose, inheritance of resistance to bacterial blights, a study of bean viruses, and testing for resistance to the common root rots. The results obtained from the studies on anthracnose and the bacterial blights are given below.

Races of Anthracnose

It is assumed that the pathogenicity of the anthracnose organism has changed considerably in the last few years, since most of the resistant bean varieties have now become susceptible. Experimental work has shown that there are two distinct groups of races, one attacking the Canario type bean varieties and the other attacking all other bean types. In the breeding program, attempts are being made to combine resistance to both groups of races in each variety. This has been partially accomplished by crossing in all possible combinations the bean varieties exhibiting different reactions to both groups of races and then field selecting the resistant progeny. Further testing of these selections is done in the greenhouse, where plants are artificially inoculated with a mixture of all available races of the pathogen.

Results from such studies have indicated that 12 selections, now in advanced generation (F_8) and with desirable agronomic characters, are resistant to about all the races so far identified. These will soon replace the Canario and some of the vining types that have become susceptible.

Bean anthracnose and rust are studied under greenhouse conditions.

Resistance to Halo Blight

In the study on the inheritance of resistance to halo blight, it was demonstrated that the resistance is dominant. This was accomplished by crossing the varieties Sanilac (resistant) and Canario 101 (susceptible); the F_2 population was then inoculated with a suspension of the causal organism *Pseudomonas phaseolicola* and the proportion of resistant to susceptible plants determined. From the χ^2 test it was concluded that the resistance is due to the complementary action of two dominant genes (9:7).

GENETIC IMPROVEMENT

In experimental work at El Horno, four yield trials were planted in which mass selections made in 1959 were compared with the commercial varieties, Bayomex, Canario 101, and Negro Mescentral. It was found that most of the selected lines tested yielded better than the commercial varieties and were very resistant to disease.

The bean improvement program has been extended to include a study of the local problems found in the States of Durango, Chihuahua, Tamaulipas, Sonora, Veracruz, Tlaxcala, Puebla, Jalisco, Guanajuato, Sinaloa, Chiapas, Aguascalientes, and Nayarit. In addition, uniform yield trials of both regional bean types and commercial varieties are being planted at all experiment stations in the Republic. Rigorous selection for promising material will be practiced at each locality.

Interspecific Natural Hybrids

A preliminary classification of *Phaseolus vulgaris*, *P. coccineus*, and the natural hybrids ("intermediate types") between these two species has been given in previous annual reports. Since the wild species *P. coccineus* and the intermediate types are resistant to disease and tolerant to insects, attempts are being made to incorporate these characters into the commercial varieties as well as into promising lines now under study. To determine to what extent these bean types are compatible, they will be crossed in all possible combinations and observations made on the F_1 and F_2 progeny.

Nutritive Value of Beans

The evaluation of protein and amino-acid content of *P. vulgaris*, *P. coccineus*, and their "intermediates" is being continued, in cooperation with the National Nutrition Institute. Since preliminary tests indicated that protein content varied according to color and size of the seed, the experiments now under way are designed to determine the percentage as well as the quality of the protein in the principal bean types. Table 1 gives the protein and tryptophan content per 100 gm. of dry material for some of the 60 seed samples analyzed. It can be seen that there is considerable variability between the two measurements. Veracruz 1-A-6, for example, is high in protein, 29.4%, but low in tryptophan, 0.27 gm. per 100 gm. of dry material. On the other hand, the protein content of Canario 101 is only 27% and contains only 0.29 gm. of tryptophan per 100 gm. of dry material.

Table 1 also shows that the protein of *P. coccineus* (Ayocotes) and the intermediate types is of much better quality, as measured by the

TABLE 1.

Protein and tryptophan content of bean varieties of the species *Phaseolus vulgaris*, *P. coccineus*, and intermediate types between the two.

Variety		Protein %/100 gm. dry material	Tryptophan gm./100 gm. dry material
Amarillo 154	*P. vulgaris*	20.56	0.25
Bayo 160	"	22.88	0.23
Canario 101	"	27.01	0.29
Jamapa	"	25.30	0.32
Negro 151	"	21.42	0.29
Veracruz 1–A–6	"	29.41	0.27
Chiapas 234–B[a]	"	26.04	0.339
Veracruz 112–A–276[a]	"	28.03	0.355
Tlaxcala 2–271	*P. coccineus*	21.87	0.505
Puebla 157–D–274	"	20.83	0.450

[a] *P. vulgaris* × *P. coccineus.*

tryptophan content, than that of any variety of the common bean, *P. vulgaris*. Because of their resistance to disease and insects as well as the quality of their protein, beans of *P. coccineus* and the natural hybrids between *P. vulgaris* and *P. coccineus* provide very promising material for the breeding program.

Table 2 gives the protein and tryptophan content of three hybrids, Bayomex, Canocel, and Negro Mescentral, now widely grown in the central plateau and the Bajío. These data indicate that protein quality was disregarded in the breeding program.

Growth Regulators

In 1959, preliminary tests indicated that it was possible to increase yield by applying minute quantities of potassium gibberellate (1 ppm) at flowering time. In 1960, more detailed experiments were conducted in which potassium gibberellate was sprayed on beans at three different stages of growth: before

TABLE 2.

Protein and tryptophan content of three hybrid lines and their parents.

Hybrid	Parents	Protein %/100 gm. dry material	Tryptophan gm./100 gm. dry material
	Canario 101	27.01	1.07
Bayomex		25.05	0.95
	Puebla 47	24.32	1.15
	Negro 152	22.80	1.25
Canocel		25.42	1.18
	Canario 101	27.01	1.07
	Canario 101	27.01	1.07
Mescentral		22.80	0.87
	Pinto 162	19.11	1.48

flowering time, at flowering time, and after flowering. Since the results indicate no significant difference among treatments, research in this project is being reduced.

Tolerance to Bean Weevil

In cooperation with the Department of Entomology of the Graduate School at Chapingo, 15 lines were compared for tolerance to the bean weevil, *Apion godmani*.

The results obtained confirm previous field observations that the preferred Canario type varieties grown in the central plateau and the Bajío are more susceptible to bean weevils than other bean types. It is one of the objectives of the section to incorporate resistance to selected insects in the future improved varieties.

PRODUCTION OF BASIC SEED

It is well known that an important phase of bean seed production and certification is the localization of producing areas where the environmental conditions hinder the development of seed-borne pathogens (anthracnose, bacterial blights). In 1960, plots were planted in semitropical arid conditions at Tepaltzingo, Morelos, and Jaral del Progreso, Guanajuato, during the winter season, using several commercial varieties such as Canario 101, Bayomex, Canocel, Negro Mescentral, Antigua, Jamapa, and Actopan. In order to determine whether or not the seed harvested in these plots was disease free, it was planted in the greenhouse along with seed harvested from crops grown at El Horno during the rainy season when heavy field infections of anthracnose and bacterial blights occur. The data obtained indicate that disease-free seed can be produced during the winter season under the semitropical conditions in the States of Morelos and Guanajuato.

SOYBEAN BREEDING AND DEVELOPMENT

Two soybean projects are now being conducted at CIANO, one pertaining to improvement and the other to cultural practices.

Twelve varieties were tested in a yield trial and observations were made on shattering, earliness, position of pods, lodging, etc. The yields of the varieties Hood, Hill, and Dorman were comparable to that of Lee (2,116 kg./ha.) and their vegetative periods (22, 39, and 39 days, respectively) were earlier than Lee. Small acreages of Dorman have been planted by several farmers but the yields obtained have been low, mainly because this variety suffers from heavy irrigation, a common practice in the Northwest. Hill has been planted commercially in the Hermosillo Valley, but owing to the relatively low humidity there it shatters readily. In the Yaqui Valley, however, where the relative humidity is a little higher, shattering with this variety is not as serious a problem.

An observation plot of 1,000 collections from the U. S. Department of Agriculture Plant Introduction Service was planted, from which plant selections were made for such characteristics as earliness, high yield, resistance to shattering, and position of pods. Only 135 were adapted and will be included in future experimental work.

The best adapted varieties, Lee, P.I. 97066 B.S., and Urquiza Arksoy, were crossed with early non-shattering varieties and lines. The purpose of this project is to obtain a variety with a vegetative period of about 120-130 days, high yield, and resistance to shattering and lodging.

In further tests to determine the best planting date for soybeans in the Yaqui Valley, five varieties were planted every two weeks for a period of ten weeks. The results indicate that the best variety, irrespective of planting dates, is Hood and that the best planting date, irrespective of varieties, is April 15—a confirmation of the data obtained in 1957, 1958, and 1959.

In general, farmers in the Yaqui Valley plant about 60 kg. of seed per hectare in rows 92 cm. apart. To study the effect of seeding rate on yield, soybeans were planted at the rates of 40, 50, and 70 kg./ha. in plots with row spacings of 75 and 92 cm. Although there was no significant difference among treatments, as measured by yield, at the highest rate lodging was observed with both row separations.

Further experiments related to adaptability of soybeans are being conducted in the Bajío, the Torreón area in northeast Mexico, the State of Jalisco, and the tropical zones of Veracruz.

New blight-resistant varieties are compared in four-row plots with the susceptible variety Alpha (foreground).

Potatoes

The potato research program has two broad aims: (1) the improvement of cultural practices and production in Mexico, and (2) the development of blight-resistant varieties that can be grown by Mexican farmers as a low-cost basic food crop. Among the more or less conventional projects included under the first heading, emphasis has been on variety trials, fertilizer tests, experiments to determine optimum dates of planting, disease and insect control, the development of new areas of potato growing, weed control through the use of herbicides, and the production of certified potato seed in Mexico.

The second main project has not only produced blight-resistant varieties that can be grown safely and economically by small farmers during the rainy season, but has also uncovered a field of basic research on *Phytophthora infestans*, the fungus causing the late-blight disease. This new research has attracted the interest of potato breeders and plant pathologists in all parts of the world.

Potato Improvement

VARIETY TRIALS

As a result of variety tests conducted nearly ten years ago, the variety Alpha was introduced on a commercial scale in Mexico. It is now grown on more than 90% of the acreage planted in the most important potato production areas, namely, León (Guanajuato), Navidad (Nuevo León), and Zamora (Michoacán). Alpha is generally accepted in Mexican markets and is currently the principal variety in the certified seed production program.

These variety trials are, of course, being continued. In the 1960-1961 season, a series of experiments was conducted comparing nearly 50 introduced and native varieties of potato. Although a number of these varieties may exceed Alpha in yield in a given year, it is necessary to have several years of testing and experience with them in all phases of production before new and definite recommendations can be made. Such characteristics as resistance to rough handling at harvest and marketing, long dormancy, color of the flesh, and adaptation to a wide variation in climatic conditions must all be considered before recommendation and release to the Mexican farmer.

FERTILIZERS

In collaboration with the soil section, a series of experiments has been conducted on a wide range of soil types, to determine the optimum fertilizer formulas for potato production in each area. In general, applications of 60 kg. of nitrogen, 120 kg. of phosphoric acid, and 30 kg. of potassium per hectare have given good results. Variations from this basic formula have given local improvement in yield, depending upon differences in soil type and previous cropping.

Definite information contributed by a large number of experiments conducted by the soil section in the region of León has led to the establishment of more efficient fertilizer practices in this region, and the newer, more practical formulas have now replaced the inefficient, often more expensive fertilizers that were used only because they were available.

HERBICIDES

As the commercial production of potatoes has gradually been shifting to larger units, mechanization has been replacing hand labor. Most important in this trend is the increased use of herbicides. Today, although the use of chemical herbicides is not general, their practical value has been demonstrated by the most progressive farmers.

In 1960, an experiment comparing herbicides with other methods of weed control showed that better yields of potatoes could be obtained with the use of herbicides (Table 1). Furthermore, use of these chemicals was cheaper than weeding by hand.

TABLE 1.

Effect of various herbicide treatments on potato yields. El Horno, 1960.

Treatment	Yield (tons/ha.)
Dinitro, 4 liters/ha.	24.1
Dinitro, 2 liters/ha.	23.7
Pre-emerge, 6 liters/ha.	23.2
Pre-emerge, 4 liters/ha.	20.1
Dinitro, 6 liters/ha.	19.9
Zimazin, 2 kg./ha.	17.8
Control, hand cultivated	16.0
Dowpon, 2 kg./ha.	13.0
Zimazin, 3 kg./ha.	12.9
Control, no weed control	10.3

CERTIFIED SEED PRODUCTION

Perhaps the most outstanding contribution made by research to potato production in Mexico has been the development of the certified seed program. Initiated in 1957 and based on experimental results gathered in previous years, the program has grown steadily and rapidly; in 1960, over 14,000 tons of potato seed were certified. In that year, for the first time in history, all of Mexico's potato seed requirements were met by locally produced seed, and there was no importation of potato seed from Europe.

This program is directed by the Department of Cultivation and Seeds of the Bureau of Plant Industry. The department has collaborated closely with the potato research group in the development of the seed certification program and has a number of former potato research men on its staff. The excellence of this cooperative effort is indicated by the results obtained. It is necessary, of course, that research continue to back up this field program. Standards must be improved, based upon sound data, so that the certified seed will be even better and find even wider acceptance.

One of the more important research projects concerns the use of cut seed. In the past, Mexican potato growers have planted small, whole seed almost exclusively. This was possible when the seed potatoes were imported, and the buyer could stipulate size of seed. Now, however, with the production of Mex-

Hybridizing potato flowers in the breeding program for late-blight resistance.

ican certified seed on a large scale, there is on the market a considerable quantity of good seed, but in the form of larger potatoes. These can be utilized for seed, of course, if the large tuber is cut into several pieces. This practice is general in Europe and the United States, but research is needed to demonstrate its practicability in Mexico.

In 1960, a series of experiments was conducted at El Horno, Santa Elena, and Navidad to determine whether cut seed was as good as whole seed under Mexican conditions. The results showed that cut seed would give yields equal to those obtained with whole seed, provided that the cut surface was allowed to suberize before planting. Manzate, Semesan, Bel, Orthocide, and lime were all found to be efficient in preventing rotting of cut seed. Suberization was accelerated when the temperature was maintained between 15-20°C. and the relative humidity could be kept above 80%.

LATE-BLIGHT CONTROL WITH FUNGICIDES

Although most potatoes in Mexico are grown under conditions that favor an escape from late blight, a gradually increasing number of farmers are finding it profitable to grow potatoes during the rainy season and control late blight with fungicides. Experiments are conducted each year to compare the efficiency of commercial fungicides in blight control.

In 1960, even though late blight appeared later than usual, the need for blight control during the rainy season was again clearly demonstrated. In an experiment at Santa Elena using the variety Alpha, 11 fungicides were compared. Eight weekly applications were made, and DDT was added to all treatments for insect control. The results are given in Table 2.

TABLE 2.

Effectiveness of 11 fungicides in controlling late blight on the variety Alpha. Santa Elena, 1960.

Material	Dosage per 50 liters	Yield of Alpha (tons/ha.)
Dithane M-22	95 gm.	37.5
Manzate (Local)	95 gm.	35.6
N-2038 (Exp.)	95 gm.	35.6
Manzate (Imported)	95 gm.	34.1
Brestan	125 gm.	33.5
Bordeaux Mixture	1:1:100	31.3
Trioxil 240	240 gm.	27.7
LO-1769-TM (Exp.)	95 gm.	27.1
LO-1769-1 (Exp.)	95 gm.	24.3
Cuprosol	125 gm.	24.1
Fungisol M	100 gm.	22.9
Control (DDT only)	—	5.4

BLIGHT-RESISTANT VARIETIES

As mentioned in the previous annual report, nine new blight-resistant varieties developed by the potato program were released to Mexican farmers in 1960. These varieties, which possess a generalized field resistance to late blight, enable the farmer to plant with the first rains of the summer season and harvest a good crop without expensive fungicides.

In the distribution of the new varieties, emphasis has been given to *ejidatarios* and small farmers. In the States of México and Michoacán this program is well advanced and hundreds of farmers with small holdings are now growing potatoes for the first time.

In 1960, an interesting experiment was conducted at Santa Elena to determine the performance of the new varieties when late blight was controlled by fungicides as well. The results, shown in Table 3, demonstrate the partial protection conferred by the field resistance of these varieties, but also indicate that at this location most of them have a yield potential at least equal to that of Alpha.

These results have several implications. First, some farmers with sufficient resources may find it profitable to spray even the blight-resistant varieties. Second, if the resistance of varieties with similar germ plasm can be increased, yields can perhaps be raised well beyond present levels. Third, there is still much to be learned about the ultimate yield potential of *Solanum tuberosum*.

TABLE 3.

Performance of nine blight-resistant varieties and Alpha with and without protective fungicidal sprays. Santa Elena, 1960.

Variety	Yield (tons/ha.) Unsprayed	Yield (tons/ha.) Sprayed	% yield increase
Erendira	45.8	69.8	52
Conchita	32.4	57.7	78
Florita	31.1	54.8	76
Greta	30.7	54.1	76
Bertita	28.3	50.7	79
Anita	27.1	46.5	72
Gabriela	26.3	51.1	94
Elenita	23.2	28.5	23
Dorita	18.7	22.1	18
Alpha	6.9	36.6	517

Onion seed production plot, CIANO.

Horticulture

During the past year demonstration home garden plots were established at all experiment stations, and broccoli seed and vegetatively propagated material of recommended asparagus and sweet potato varieties were produced and distributed to farmers as part of the national home garden program. A new tomato variety, Culiacán 1, has been established for the Pacific Coast winter production region.

RESULTS BY STATIONS

EL HORNO

Pepper Improvement

Evaluation of lines and new accessions was continued, and selfed seed was obtained from selected plants of 61 lines of Ancho, 23 lines of Mulato, 22 lines of Pasilla and Sandía, 6 lines of Jalapeño, 28 lines of Güero, and 13 lines of new accessions.

In the cooperative project with the plant pathology section, 11 lines were selected as being highly resistant to *Phytophthora capsici*, the causal agent of root rot and wilting.

Studies to determine the best stage for effecting controlled cross-pollination have now been concluded. Half-opened flowers in full dehiscence have proved to be the best as pollen donors, and buds about to open and half-opened flowers before dehiscence the best as female flowers.

In comparative yield tests with selections of Mulato pepper, all four lines gave significant increases in yield of fresh product over the commercial variety used as a check (Table 1). The product was also very uniform. Plants of the line 60C-30PA were of outstanding size and vigor but showed susceptibility to *Phytophthora*. The other three lines were used to form a synthetic variety.

In another trial of selections from 11 lines of the variety Ancho, line 60C-3 selfed yielded over 30 tons/ha. of excellent fruits. It is being multiplied for release as a new variety,

TABLE 1.

Yields of selected lines and a local commercial variety of Mulato pepper. El Horno, 1960.

Line	Yield (tons/ha.)
60C–26 (selfed)	33.6
60C–16PA	33.5
60C–30PA	29.7
60C–20 (selfed)	28.2
60C–31 (check)[a]	21.9
L.S.D. at 5%	3.8

[a] Obtained in San Martín de Texmelucán, Puebla.

and the other 10 lines, which also outyielded the checks, will be used to form a synthetic variety.

Winter Squash Breeding

Collection of local types of squash has been continued. Improvement work in progress follows the standard procedures of selection, inbreeding, evaluation of agronomic performance, and rating of the quality of flesh of superior types on the basis of baked and autoclaved samples of mature fruits. Ten of the most promising lines in quality tests performed in 1959 and 1960 will be tested further this year.

In taxonomic studies of the cultivated winter squash varieties, fruits of each plant were harvested separately to evaluate the variability within a plant and between plants of the same collection. Peduncles and seeds used for taxonomic identification were collected and will be closely studied.

Other Vegetables

Variety trials were conducted with celery, snap beans of the pole type, garden peas, sweet corn, and spinach. In observation trials of 11 collections of husk tomato (*Physalis* spp.), a vegetable widely used in making sauces, there was great diversity of types in regard to color, size, and flavor of the fruit. Yields ranged from 15.5 to 33 tons/ha.

In order to meet the increasing number of requests for seed and crowns of the asparagus variety UC-309, a 1-acre plot for seed production was planted, in which one-year selected crowns were interplanted at the rate of five females to one male. A total of 4,000 one-year male crowns has been given to the National School of Agriculture for planting in a demonstration plot, and an equal number was released to the Government of the State of México for distribution among farmers as part of a home garden program.

SANTA ELENA

Yield tests conducted on cabbage, snap beans, garden peas, cauliflower, and huauzontle (*Chenopodium nuttalliae* Saff.) basically confirmed results previously obtained. In a broccoli yield test, Spartan Early was the best variety, with an average yield of 64.7 tons/ha.

Climatic conditions in the Toluca Valley are ideal for celery growing. The results of preliminary observation trials with four varieties are summarized in Table 2. Utah Tall Green was outstanding in quality, average weight of plant, and yield.

Thirty-two superior lines of horse beans (*Vicia faba* L.) have been selected from 148 individual selections made in 1959, and will be studied intensively for further possible release of an improved type.

TABLE 2.

Performance of four celery varieties. Santa Elena, 1960.

	Petiole		Av. wt. of	Yield
Variety	Length (cm.)	Quality[a]	plant (kg.)	(ton/ha.)
Utah Tall Green	26	9	0.800	36.4
Summer Pascal	17	9	0.570	26.9
Utah–15	28	5	0.600	23.2
Golden Self Blanching	20	7	0.540	21.0

[a] Scale of 9 = excellent, 1 = poor.

Fruit of the new tomato variety Culiacán 1.

TEPALTZINGO, MORELOS

In trials conducted at this semitropical location in cooperation with the National Corn Commission, the following varieties showed the best adaptation:

Beets: Detroit Dark Red, Green Top Bunching. *Snapbeans:* (pole type) Extender; (bush type) Wade, Contender. *Summer Squash:* Caserta. *Winter Squash:* Line 135-A. *Melon:* Rio Gold, Georgia 47. *Cucumber:* Stono. *Watermelon:* Congo, Black Diamond. *Head Lettuce:* Great Lakes, 66-I.M. *Leaf Lettuce:* Paris Island Cos. *Carrots:* Nantes A-17, Scarlet Nantes. *Okra:* White Velvet.

In a test of the field performance of 215 lines of tomato crosses between *Lycopersicum esculentum* and *L. peruvianum*, fruits were evaluated for firmness, color, size, uniformity, and resistance to sunscald. A number of lines produced fruits of outstanding firmness and their selections will be used in further breeding work.

CIANO

Recent spacing experiments with garlic varieties indicate that the highest yield may be obtained when two rows are planted on beds spaced at 0.92 m., but that the proportion of large-sized bulbs is lower than when single rows are planted on the beds. The results of experiments on the influence of clove size confirm earlier studies in the Bajío, which showed that large cloves give the highest yield.

In yield trials with onions, a yellow onion of the variety Texas Grano 502 gave the highest yield, 62.9 tons/ha.; the best white onion was Asgrow W-10, which yielded 56.7 tons/ha. Yield tests were also conducted on melon, lettuce, beets, and carrots.

In continuing studies on seed production of onion, broccoli, and lettuce quantities of 6.5 kg. of onion seed and 210 kg. of broccoli seed were produced experimentally (data on lettuce seed production are not yet available). The broccoli seed was released to the Bureau of Plant Industry for distribution through the national home garden program.

CULIACAN, SINALOA

At this location, experimental work is carried out in cooperation with private growers and includes yield tests of both commercial tomato varieties and lines from the Southern Tomato Exchange Program (STEP), as well as tests on cucumber and melon.

During the past year, the tomato line STEP 282 was established as a new variety for the Valley of Culiacán and given the name Culiacán 1. Since its first trial, this variety has consistently shown such desirable characteristics as high total yield, high-quality fruit, firmness, and resistance to sunscald. Despite the fact that it was discarded by the STEP organization, it has proved to be outstanding in the Culiacán area.

THE BAJIO

The recommended sweet potato varieties Cuitzeo and Catemaco were multiplied and then released to the National Corn Commission for distribution to farmers.

In trials of several products for control of nematodes on strawberry, ethylene dibromide at 42 liters/ha. was the most effective treatment. Experiments on date of strawberry transplanting showed that the period between August 1 and September 30 was the most satisfactory from the standpoint of subsequent fresh fruit production.

COTAXTLA

The germ plasm bank of variety collections of sweet potato, "taro" (*Colocasia esculenta*) and cassava (*Manihot esculenta*), was preserved and increased with new accessions.

In a 1960 yield trial, a relatively new tomato variety, Marion, significantly outyielded Cotaxtla I, 38.3 tons/ha. versus 29.7 tons/ha. The quality characteristics of Marion and its general adaptation to winter growing conditions in the Veracruz area suggest that it may be a valuable addition to the horticultural crop varieties presently recommended for this zone.

Strip grazing of alfalfa in the Valley of Mexico.

Forage Grasses and Legumes

Greater emphasis was placed on the evaluation of forage and pasture productivity in terms of animal responses during the past year. Forage utilization studies were also initiated. Range management investigations were expanded on La Campana Experimental Range, with a corresponding increase in herd size to 60 yearling steers. In the tropics at the Cotaxtla station, a total of 88 head of livestock is either currently being used in forage trials or will be included shortly in new studies.

RANGE MANAGEMENT IN CHIHUAHUA

STEER PERFORMANCE ON LA CAMPANA

Because of the great amount of unutilized forage remaining on the alkali swale pasture site after the completion of the stocking rate study in November, 1959, the experimental treatments were modified for 1960. The number of hectares per yearling steer was reduced from 8 to 5 hectares per animal for the heavy rate and from 12 to 7.5 hectares per steer for the moderate stocking rate. This resulted in a total of eight steers in each pasture instead of five as in 1959. The supplemental feed rations during the dry season remained unchanged.

As shown in Table 1, the daily average steer gains registered for the grazing period of 304 days during 1960 were considerably below those obtained in the previous year. The steer yields per hectare were very comparable for the two years because the number of steer grazing days per hectare was greater in 1960 than in 1959.

In contrast to the results obtained in 1959, the use of supplements significantly increased liveweight gains over the use of salt alone. There was no apparent benefit derived from the addition of bonemeal to the ration of cottonseed meal.

The differences in animal responses in the two years can probably be explained on the

TABLE 1.

Steer production on an alkali swale pasture site at La Campana, February 1—November 1, 1959, and January 2—November 1, 1960.

Stocking rate	Supplement[a]	Liveweight gain (kg.) Total 1959	Total 1960	Daily 1959	Daily 1960	Steer yield per ha. (kg.) 1959	1960
Heavy (1959: 8 ha./steer 1960: 5 ha./steer)	Salt	165.0	90.3	0.60	0.30	20.63	18.05
	Salt + cottonseed meal	173.1	122.3	0.63	0.40	21.64	24.45
	Salt + cottonseed meal + bonemeal	173.1	112.3	0.63	0.37	21.64	22.50
	Average	170.4	108.3	0.62	0.36	21.30	21.67
Moderate (1959: 12 ha./steer 1960: 7.5 ha./steer)	Salt	193.0	107.6	0.71	0.35	16.08	14.35
	Salt + cottonseed meal	185.5	125.3	0.68	0.41	15.46	16.70
	Salt + cottonseed meal + bonemeal	190.3	138.5	0.70	0.46	15.86	18.47
	Average	189.6	123.8	0.70	0.41	15.80	16.51

[a]Daily ration per head of supplements utilized, in grams:

	Jan.	Feb.	Mar.	Apr.	May	June
Salt	30	30	30	30	30	30
Cottonseed meal	500	500	500	250	250	250
Bonemeal	75	75	75	75	75	75

During the remaining months all steers had access to salt.

basis of the phenomena of selective grazing. Despite the fact that *Bouteloua gracilis*, blue gramagrass, is not commonly found in alkali swales, it was quite abundant at the beginning of the study in 1959 because it was favored by the year-long rest period that occurred while the fence and water installations were being completed. In comparison with the predominant grasses, namely *Sporobolus airoides* and *Eragrostis obtusiflora,* blue gramagrass is more nutritious and palatable. During 1959 the steers grazed the blue gramagrass very heavily in preference to the coarser grasses, thereby obtaining an unusually good diet and minimizing the effect of supplementation. During 1960, however, very little blue gramagrass was available to the steers, and they were therefore obliged to utilize the less nutritious species, a fact which possibly explains the benefit derived from the use of supplements during the dry season.

CHEMICAL CONTROL OF ALFOMBRILLA

Good permanent control of alfombrilla (*Drymaria arenarioides*) was obtained with several of the newer herbicides utilized in the screening trials last year. Best kill resulted from the use of Silvex combined with the wetting agent, Dynawet. Ammonium triozol also gave results considerably better than 2,4,5-T ester, the most promising chemical in trials the previous year. The Chihuahua Cattlemen's Association, in cooperation with the Ministry of Agriculture, has organized a large-scale control program which will be initiated this summer. The La Campana station is providing the technical direction.

Forage Evaluation in the Tropics

FEEDING TRIAL WITH STEERS

The use of silage during the dry season is gaining wide acceptance among cattlemen in the tropics. Not only is there a growing appreciation of the value of silage for maintaining cattle during the dry season, interest is also being demonstrated in feed-lot fattening of cattle. A feeding trial based on Merkeróngrass silage has been initiated in which different levels and sources of protein are included in the treatments. A reinforced trench silo has been constructed next to the small feed lot and filled with chopped Merkeróngrass to which molasses was added. The construction, filling, and utilization of the silo have also served as an excellent demonstration to visiting ranchers. Although the feeding trial is still in progress, the steers receiving protein supplementation are averaging daily gains of over 1 kg. whereas the steers receiving only silage are just maintaining their weight.

GRAZING TRIAL

Fence construction and water facilities for cattle have now been completed in the experimental pasture unit. This unit consists of six tropical grasses individually established in 1-hectare pastures with two replications of each. Cattle will be introduced during the summer. Each pasture will be managed separately for the purpose of obtaining the optimum grazing pressure for each grass species.

Alfalfa Improvement

During 1960, a polycross nursery containing 90 clones resistant to the spotted alfalfa aphid, *Therioaphis maculata* (Buckton), was established at the La Cal Grande station. Each clone was replicated 14 times and individually randomized within the crossing block. In addition, 54 clones were selected for their resistance to downy mildew, *Peronospora trifoliorum*, from the disease nursery of 3,000 plants at Santa Elena. These clones were also vegetatively propagated to provide 15 replications of each. Polycross seed is currently being harvested from both crossing blocks, and progeny tests will be conducted this fall.

Forage Crops Management

As described in previous reports, the forage

Silage is being used increasingly to alleviate the shortage of green forage during the dry season in the Gulf Tropics.

production of the napiergrass variety, Merkerón, declines drastically during the winter dry season although this grass has been consistently the highest yielder among the perennial tropical grasses during summer. The first year's data have been obtained from a replicated yield trial that includes different levels and times of application of nitrogen fertilizer with and without dry season irrigation practices. Providing moisture to Merkerón during late fall and winter did not stimulate greater growth during this period. An early fall application of 80 kg./ha. of nitrogen increased yields up to approximately 2 tons/ha. of dry matter, as compared with about 0.5 ton for the check both with and without irrigation. The harvest was made in January. Irrigation greatly stimulated vegetative growth during the spring preceding the rainy season. The average yield of the non-irrigated grass in May was less than 1 ton/ha. of dry matter, compared with over 4 tons for the irrigated plots. There was some residual beneficial effect observed from the fall nitrogen application.

A corn-velvet bean association at corn harvest.

Soil Fertility and Management

Investigations in soils are directed toward the determination of economical means of making the soil a more favorable medium for plant growth. The soil properties that most frequently limit crop yields in Mexico—deficiencies in available nitrogen, phosphorus, and soil moisture—have continued to receive major attention. Research on the residual effects of cropping practices on soil productivity has been continued.

During the past year, soil fertility studies were carried out at the El Horno, Santa Elena, Cotaxtla, and CIANO experiment stations, and in cooperation with farmers in the State of Michoacán and in the Valley of Mexico. Most of the studies were made with corn, wheat, and potatoes; others involved cotton, beans, alfalfa, sesame, and sorghum. Soil moisture studies were carried out with wheat at CIANO and with alfalfa at El Horno.

In the following pages the results are presented of the fertility studies conducted in the Sierra Tarasca and the Valley of Mexico. In addition, brief summaries are given of a four-year study of the fertilization of alfalfa in the Valley of Mexico and a three-year study of corn-legume associations at Cotaxtla.

Corn and Potato Fertilization in the Sierra Tarasca

Preliminary studies in the Sierra Tarasca indicated that applications of nitrogen, phosphorus, potassium, and calcium have relatively little effect on crop yields, even though yields are low. In 1960, more detailed studies were carried out on the response of corn to these four elements as well as to chicken manure and certain minor elements, and on the response of potatoes to nitrogen, phosphorus, potassium, and manure. Phosphorus was given major consideration, since preliminary observations indicated that the soils were particularly deficient in this element.

The area selected for study lies generally within a triangle made by connecting Pátzcuaro, Acámbaro, and Ario de Rosales in the

State of Michoacán. The experiments were located at elevations between 2,000 and 2,750 m. above sea level. All of the soils were medium-textured, formed from deposits of volcanic ash, and quite deep and well drained. The pH values of the surface horizons varied from 5.4 to 6.4, and the organic matter percentages from 6.3 to 13.2. The carbon:nitrogen ratios were quite high, averaging about 13.5. All soils were low in available phosphorus and high in active aluminum. Exchange capacities were high owing largely, perhaps, to the high organic matter contents. The percentage of saturation with calcium varied from 4 to 34, with magnesium from 2 to 10, and with potassium from 0.6 to 3.5; the percentage of saturation with cations varied from 9 to 56. These values are low considering the pH values of the soils, probably because a large part of the exchange capacity is contributed by the organic fraction.

Corn experiments, using local unimproved varieties, were conducted at seven locations: San Gregorio, Casas Blancas, La Cruz, La Cantera, Molino de San José, San Juan de Viña, and Ario de Rosales. At the first six, the corn was planted with residual moisture between March 10 and April 7; the planting at Ario de Rosales was made on June 21 at the beginning of the rainy season. At the highest location, San Gregorio, frost on November 1 killed the corn before physiological maturity. In the other experiments, the time between planting and maturity varied from about 195 to 225 days. The soil was adequately supplied with moisture throughout the growing season at all sites.

Large yield increases resulted from the application of phosphorus (up to 400 kg./ha. of P_2O_5) in all but two experiments, Molino de San José and Ario de Rosales. Nitrogen (60 kg./ha.) increased yields significantly except at San Gregorio and La Cruz. Potassium (40 kg./ha.) significantly increased the yield at San Gregorio but decreased it at Casas Blancas, while at both these locations yields were significantly increased by molybdenum (200 gm./ha. in the form of ammonium molybdate). There was an indication that yields were increased by aspersions of manganese and zinc at Ario de Rosales. Yields were slightly higher in most experiments with the application of calcium (220 kg./ha. of $Ca(OH)_2$), but differences due to this element were not significant.

The surprising result in this study was the magnitude of the response to the application of 20 tons of chicken manure plus 200 kg. of P_2O_5 per hectare. The average increase in ear corn yield with this treatment was 3.75 tons/ha. At the four sites most centrally located in the sierra—San Gregorio, Casas Blancas, La Cruz, and La Cantera—the yield increase from this treatment averaged 2.18 tons/ha. or 105% more than the largest increase obtained with nitrogen and phosphorus alone; at the three sites along the limits of the sierra, the increase averaged 1.00 ton/ha. or 47% more than the largest increase with nitrogen and phosphorus alone. The effect of phosphorus and manure plus phosphorus in the four centrally located experiments is shown graphically in Figure 1.

Potato experiments were planted at three locations in the sierra. The application of 60 kg./ha. of nitrogen increased yields by an average of 4.18 tons/ha., while a second increment of 60 kg. of nitrogen decreased yields by an average of 1.05 tons/ha. With the application of 200 kg./ha. of P_2O_5, the average yield

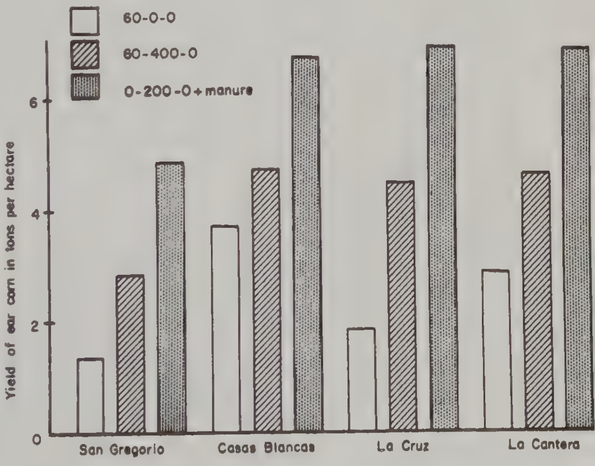


Figure 1. Effect of three fertilizer treatments on ear corn yields at four locations in the Sierra Tarasca.

increase was 4.90 tons/ha. Phosphorus plus manure resulted in yields similar to the best yields obtained with nitrogen and phosphorus alone.

These results indicate that, in comparison with chemical fertilizers, chicken manure was relatively more effective in increasing corn yields than in increasing potato yields, and, in addition, was relatively more effective at sites centrally located within the sierra than at those along the limits. From these results it appears that the nutrition of corn in the sierra soils is adversely affected by some deficiency or toxicity which is eliminated more effectively by chicken manure than by chemical fertilizers.

Several greenhouse experiments have been carried out to study the effectiveness of different soil treatments in eliminating this nutritional problem. Romaine lettuce, alfalfa, and oats were used as indicator crops. The data obtained thus far may be summarized as follows:

The application of phosphorus resulted in increased yields of all three crops, the increase being relatively greatest for lettuce. Nitrogen plus phosphorus did not affect lettuce yields and nitrogen alone depressed yields. None of the crops responded to potassium, magnesium, manganese, copper, or zinc. Low rates of liming increased yields slightly and were most effective at the higher rates of phosphorus fertilization. With lettuce, application of 25 tons/ha. of chicken manure at the time of transplanting resulted in a yield increase equivalent to about 650 kg./ha. of P_2O_5; a larger increase was obtained when the manure was applied three weeks before transplanting. The active aluminum content of the soils was reduced by the application of phosphorus.

These studies of the fertility of the sierra soils are being continued.

CORN AND ALFALFA FERTILIZATION IN THE VALLEY OF MEXICO

CORN

Fertilizer experiments with local varieties of corn were carried out on eight private farms in the southeastern part of the Valley of Mexico, at elevations between 2,300 and 2,450 m. above sea level. All of the soils were light-textured, fairly level, and formed from volcanic ash. The pH values of the surface horizons varied from 5.6 to 6.7, and organic matter percentages from 0.62 to 2.23. Seven of the soils were low or medium in available phosphorus and five were low or medium in available potassium.

The experiments were planted with residual moisture between March 29 and April 19. Adequate soil moisture was available to the corn after the beginning of the rainy season near the end of May.

Yields were increased significantly by the application of nitrogen in four experiments, by phosphorus in one experiment, and by potassium in two experiments. Vegetative responses observed in the one experiment harvested by a farmer indicated that both nitrogen and phosphorus were deficient at that location. In three experiments, ear corn yields varied from 5 to 7 tons/ha. and there were no significant effects of the fertilizer.

At the four locations where nitrogen deficiencies were observed, the average effect of the application of 80 kg. of nitrogen was an increase in ear corn yield of 2.66 tons; that is, each kg. of nitrogen increased the yield of ear corn by 33 kg. In one experiment, the application of 120 kg./ha. of P_2O_5 increased ear corn yields by 2.34 tons/ha. In two experiments, the application of 40 kg./ha. of K_2O increased ear corn yields by an average of 1.07 tons/ha.

ALFALFA

A study of the effects of applications of phosphorus and barnyard manure on the production of alfalfa has been in progress at El Horno for four years. The total production during this period was increased from 55.0 to 81.8 tons/ha., or by 48%, with the application of 320 kg./ha. of P_2O_5; that is, each kg. of P_2O_5 increased yields by 84 kg. of dry alfalfa.

The degree to which phosphorus fertilization increased alfalfa yields was influenced by the age of the alfalfa planting. During the first year, yields were not increased appreciably by applications of phosphorus. During the second year, there was response to both low and high rates of phosphorus fertilization, but no yield advantage resulted from the latter. In the third year, yields were relatively greater as the rate of fertilization increased. During the fourth year, the plots fertilized with the low rates of phosphorus produced about the same as the check, while those fertilized with the high rates continued to yield much more than the check. All yields in the fourth year were considerably lower than in the third, however, because of the operation of a disease factor.

When alfalfa production with applications of 10 and 40 tons/ha. of barnyard manure was compared with the yields obtained with the different rates of phosphorus fertilization, it was found that, on the average, each ton of manure increased yields by an amount approximately equivalent to 4.2 kg. of P_2O_5 applied in the form of superphosphate.

A comparison was also made between two methods of applying 160 kg./ha. of P_2O_5: all at planting time, and 40 kg./ha. at planting and 40 kg./ha. in December of each following year. Application of all the phosphorus at planting time was 24% more effective.

CORN-LEGUME ASSOCIATIONS AT COTAXTLA

The growing of legumes in association with corn and other crops has been widely studied as a means of adding nitrogen and organic matter to soils. Corn-legume associations are of considerable interest in Mexico for two reasons: (a) most of the rainfall occurs during the growing season of the corn, so that legumes can be produced only during this period; and (b) soils used in the production of corn are generally deficient in available nitrogen, and it is often uneconomical to correct this deficiency with commercial nitrogen because of the erratic nature of the precipitation.

Three years' data are now available from an experiment begun at Cotaxtla in 1958 to study the association of velvet bean (*Stizolobium deeringianum*), jack bean (*Canavalia ensiformis*), Sesbania (*Sesbania* sp.), and Crotalaria (*Crotalaria juncea*) with corn planted in the summer in 92-, 138-, and 184-cm. rows. The legumes were seeded in the extra space between the corn in the 138- and 184-cm. rows shortly after corn planting and were seeded between the 92-cm. rows at the last cultivation. The corn population was maintained constant at 40,000 plants per hectare.

The yields of corn planted in 92-, 138-, and 184-cm. rows, averaged for the three years and the four legumes, were 3.75, 3.38, and 2.97 tons/ha., respectively. In other words, increasing the distance between rows by 50% resulted in a 10% reduction in yield, while doubling the distance between rows resulted in a 21% reduction in yield.

The average dry-weight yields of velvet bean, jack bean, and Crotalaria for the three row widths during the three years were roughly 4.8, 3.4, and 1.3 tons/ha., respectively. Sesbania grew little in these associations and matured earlier than the corn. Increasing the distance between rows from 92 to 184 cm. increased the production of velvet bean by 11%, of jack bean by 68%, and of Crotalaria by 284%.

The average nitrogen percentages of velvet bean, jack bean, and Crotalaria on a dry-weight basis were 3.16, 2.91, and 1.85, respectively. With winter corn crops planted in 1959 and 1960 following incorporation of these legumes, ear corn yields were increased by averages of 0.64, 0.59, and 0.36 tons/ha., respectively.

Both velvet bean and jack bean grew well in these associations and produced acceptable quantities of dry matter and nitrogen. Velvet bean, however, covered the corn plants before maturity and made the harvest more difficult. Crotalaria developed poorly, evidently because of its sensitivity to shading by the corn, and produced little dry matter with a low nitrogen percentage. Sesbania is apparently not adapted when planted, as in this study, during June and July.

Entomology

The research efforts of the entomology section continue to be directed toward the development of appropriate means to reduce losses by damaging insects to basic food crops both in the field and in storage. Studies are designed to provide immediate chemical control recommendations and also the more detailed knowledge needed to refine the use of insecticides and other more permanent means of control, such as plant resistance and the use of parasites and predators. During 1960–1961, the major part of this work was centered at El Horno, CIANO, and Cotaxtla.

Of special importance during the past year was the participation of members of the section in the Second National Congress of Entomology and Plant Pathology held at Chapingo during November, 1960, where scientists from all the major research and teaching institutions in the Republic benefited from a week of both formal and informal exchange of information.

Insect Collection and Survey

The routine survey collections of injurious insects and their natural enemies have been continued at all major research centers. Following the identification of this material by specialists, it is being added to the reference insect collection at El Horno.

Of special interest during the year was the discovery of a new species of the Order Strepsiptera found at Cotaxtla parasitizing *Sogata cubana* (Crawf.), the vector on grasses of the "hoja blanca" rice disease. This species has been described by Dr. W. Dwight Pierce, of the Los Angeles County Museum, as *Sogatelenchus mexicanus*, type species of a new genus, the first in the Family Elenchidae to be reported south of the United States. Paratypes have been deposited in the El Horno collection.

Biological and Ecological Studies

BEAN LEAFHOPPER

During the spring and summer of 1960, detailed insectary studies were initiated at Cotaxtla on the biology of the leafhopper, *Empoasca krameri* R. & M., which occurs commonly throughout Central America and is one of the two principal pests of beans in the Veracruz area. Both nymphs and adults feed on the underside of the foliage, causing a curling and burning of the leaves and a general stunting of plants. From April through July in the insectary, the complete biological cycle from egg to adult varied from 11 to 19 days; females deposited an average of 54 eggs in a 10-day period. This relatively short biological cycle was confirmed in the field where peak populations have in general developed during the dry season from February through May.

ALFALFA DEFOLIATOR

At El Horno, routine light-trap collections have commonly contained a Phalaenid moth, *Leucochlaena hipparis* (Druce). Although this species has not generally been reported of economic importance in cultivated crops, it is a potential pest in the high altitude valleys of Mexico. Preliminary trials indicated that *L. hipparis* can easily be reared in the laboratory on alfalfa foliage and is tolerant to bacterial diseases that attack insects of this group under laboratory conditions. During 1960, detailed biological studies were conducted at El Horno to accumulate fundamental information that may be needed for future control recommendations and to develop laboratory rearing techniques for this promising test animal. The results of host preference studies show that *L. hipparis* prefers alfalfa for oviposition above bean, cabbage, corn, lettuce, or amaranth. Larval survival rate and growth were also greatest on alfalfa, where a total of 43 days was required for development from egg to adult. Light-trap collections indicate that there are six generations yearly of this species in the Valley of Mexico.

SOYBEAN THRIP

At CIANO, studies were initiated in the spring of 1960 on the biology of the thrip, *Hercothrips phaseoli* (Hood), one of the two major pests of soybeans. Considerable time was needed to develop the special laboratory

The life cycle stages of *Leucochlaena hipparis* (Druce), a potential pest of alfalfa.

techniques required. In the insectary, an average of 13 days was required for development from egg to adult. The fact that this minute insect passes through two nymphal stages feeding on the plant leaf and a prepupal and pupal stage in the soil, makes control measures with foliage insecticides especially difficult. In the field, thrips generally appear on the plants in May, with maximum populations developing during July and August. Severe foliage damage and yield reductions have occurred when population levels of adults have reached 20 or more per leaflet.

RICE DELPHACIDS

Following confirmation of the presence of the Delphacid vectors of the "hoja blanca" rice disease at Cotaxtla, *Sogata orizicola* Muir and *S. cubana* (Crawf.), studies were initiated on the biology of these two species. Field observations have indicated that *S. orizicola*, the vector on rice, prefers rice and pará grass (*Panicum purpurascens*) as hosts, while *S. cubana*, the grass vector, is found almost exclusively on barnyard grass (*Echinochloa colonum*). Peak populations of *S. orizicola* correspond with the summer rice season, while maximum populations of *S. cubana* occur from August through October and from December through February. In the insectary both species required from 22 to 28 days for development from egg to adult; in cages, adults have lived from 20 to 40 days. "Hoja blanca" transmission studies at Cotaxtla with these two species on both rice and barnyard grass have produced negative results to date.

CHEMICAL CONTROL STUDIES

PESTS OF CORN

Several new foliage insecticides were included in the routine chemical control experiments on corn this year for comparison with an endrin spray, the current recommendation.

At Cotaxtla in two separate tests, two applications of granular telodrin (0.5 kg. technical/ha.) and granular endrin (0.5 kg.) gave excellent control of the fall armyworm, *Laphygma frugiperda* (J. E. Smith), while granular heptachlor (0.5 kg.) and sprays of telodrin emulsion (0.2 kg.), endrin emulsion (0.2 kg.), and Sevin wettable powder (1.2 kg.) were slightly less effective. The bacterial insecticide, *Bacillus thuringiensis* Ber. (1.8 kg.) failed to give control. None of these treatments gave control of the neotropical corn stalk borer, *Zeadiatraea lineolata* (Wlk.), or resulted in yield increases.

At CIANO in the spring planting, three applications of Sevin wettable powder (1.0 kg.), granular endrin (0.3 kg.), telodrin emulsion (0.2 kg.), and endrin emulsion (0.1 kg.) gave effective control of *L. frugiperda*, while Dipterex (1.0 kg.) and *Bacillus thuringiensis* (2.0 kg.) gave poor control. In the summer planting, Shell 50 emulsion (0.2 kg.) and granular endrin (0.3 kg.) gave significantly better control of *L. frugiperda* than did Sevin wettable powder (1.0 kg.), *B. thuringiensis* (2.0 kg.), or Dipterex (1.0 kg.). In this test the best treatment, granular endrin, produced a yield increase of 1 ton/ha. over the untreated check.

PESTS OF BEANS

In preliminary tests both in the laboratory and in the field at El Horno, the new carbamate insecticide Sevin has exhibited excellent residual effect against the Mexican bean beetle, *Epilachna varivestis* Muls. At Cotaxtla this same material has been very effective against the banded cucumber beetle, *Diabrotica balteata* Lec.

PESTS OF WHEAT AND BARLEY

In general only slight losses were caused by the English grain aphid, *Macrosiphum granarium* (Kirby), on wheat heads and by the corn leaf aphid, *Rhopalosiphum maidis* (Fitch), on barley foliage in the Yaqui Valley during the 1960–1961 season. Populations of a third species, *Rhopalosiphum rufi abdominalis* (Theob.), were very common on the roots of small wheat and barley plants during January, and caused some yellowing of the foliage. In a preliminary test at CIANO, a metasystox spray (0.2 kg.) effectively reduced populations of this aphid. However, since this control was not reflected in increased yields, it appears that the plants were able to recover from this early season injury.

HOJA BLANCA VECTOR

At Cotaxtla during the fall and winter of 1960, two tests were conducted in the field to study the toxicity of several insecticides to *Sogata cubana* on grass. In the first, sprays of Sevin (1.2 kg.), DDT (1.2 kg.), endrin (0.6 kg.), and lindane (0.6 kg.) all effectively reduced populations for 10 days. In the second test, DDT (0.6 kg.), metasystox (0.3 kg.), and endrin (0.3 kg.) were effective, but aldrin (0.2 kg.) gave poor control.

PESTS OF SOYBEANS

At CIANO in a test of foliage sprays for the control of thrips, *Hercothrips phaseoli*, on soybeans, malathion (1.0 kg.), Sevin (1.0 kg.), endrin (0.3 kg.), dieldrin (0.3 kg.), telodrin (0.3 kg.), toxaphene (1.5 kg.), DDT (1.5 kg.), thiodan (0.5 kg.), and heptachlor (1.0 kg.) all showed promise on the basis of counts of nymphs 120 hours after a single application. Methyl parathion (0.5 kg.) and Dipterex (1.0 kg.) gave poor results. Further studies are needed, especially on the timing of application against the pest.

A second major pest of soybean, the saltmarsh caterpillar, *Estigmene acrea* (Drury), has defoliated large areas of the crop in the Yaqui Valley during the past two growing seasons. Dipterex (1.0–1.5 kg.) and ethyl parathion (0.8 kg.) have given excellent control of *E. acrea* in commercial plantings when applied before the larvae reach the later instars. Where control was effective, yields in the Valley varied from 1 to 2.25 tons, while fields where the insect was not controlled produced 0.3 to 0.9 ton. Data from an artificial defoliation experiment at CIANO indicated that a yield reduction of approximately 0.5 ton resulted from a manual defoliation at the time of caterpillar attack, a result comparable to losses observed in commercial fields. Unfortunately, the farmers tend to neglect their soybean plantings at the time *E. acrea* control is needed because they are occupied with the cotton harvest.

Sweeping alfalfa to estimate populations of aphids and their natural enemies.

SPOTTED ALFALFA APHID

The two-year insecticide study at CIANO on the control of the spotted alfalfa aphid, *Therioaphis maculata* (Buckton), was terminated in the fall of 1960. Increases in production of as much as 5 tons in individual cuttings resulted from the control obtained with treatments such as metasystox (0.06–0.2 kg.) and malathion (0.5–1.4 kg.). In addition, stand reductions from 150 plants per square meter in insecticide-treated plots to 60 per meter in the untreated checks were noted after the two-year cropping period. This level of population is not considered sufficient for continued production.

ALFALFA DEFOLIATOR

In the laboratory at El Horno, the toxicity of seven insecticides to larvae of the Phalaenid moth, *Leucochlaena hipparis*, was evaluated. Median lethal concentrations in grams per liter of the insecticides tested were: endrin

0.2, heptachlor 0.2, DDT 0.3, methyl parathion 0.3, toxaphene 0.4, rotenone 1.2, and *Bacillus thuringiensis* 4.8. These data are valuable aids in the prediction of effective concentrations for field applications against *L. hipparis* and related species.

PESTS OF COTTON

At CIANO, a 10% granular thimet formulation applied at the rate of 3 kg./ha. in band and broadcast before planting and in band after plant emergence failed to control thrips, *Frankliniella occidentalis* (Perg.), on seedling cotton.

Experimental plots in the Rio Muerto area of the Yaqui Valley, in a cooperative study with local representatives of the Bureau of Plant Protection, provided data on the control of several common cotton pests with seven different insecticides used individually and in combination with DDT and, in addition, provided data on the toxicity of these chemicals to the beneficial insects present.

BIOLOGICAL CONTROL STUDIES

PARASITES OF THE SPOTTED ALFALFA APHID

Two species of parasites of the spotted alfalfa aphid have become established in Mexico as a result of releases during the past two years and are beginning to aid in the control of this damaging aphid. *Trioxys utilis* Muesebeck was found to be common in several alfalfa fields in the Yaqui Valley in June, 1960, and *Aphelinus semiflavus* Howard was found in fields in an area about 6 kilometers in diameter near Celaya, Guanajuato, in the Bajío in March, 1961. A few individuals of *T. utilis* and *Praon palitans* Mues. were found in a field at El Horno this spring, but numbers were not sufficient to confirm establishment of these species in the Valley of Mexico. Cultures of all three species are being maintained at El Horno as a source of material for further releases.

PARASITE OF THE RICE DELPHACIDS

Discovery at Cotaxtla of the strepsipterous parasite of *Sogata cubana*, the grass vector of the "hoja blanca" rice disease, has added valuable information to previous knowledge of the Family Elenchidae. In a September 1960 collection of *S. cubana*, 60% of the individuals were found to contain these parasites. From this collection and a more recent one made in January, Dr. W. Dwight Pierce of the Los Angeles County Museum has described the greater part of the life cycle of this new species, *Sogatelenchus mexicanus*. Further studies are needed to determine in more detail the influence of *S. mexicanus* on populations of *Sogata cubana* and related species at Cotaxtla, as well as to evaluate the possible use of this parasite to control vectors of "hoja blanca" in other rice-growing areas.

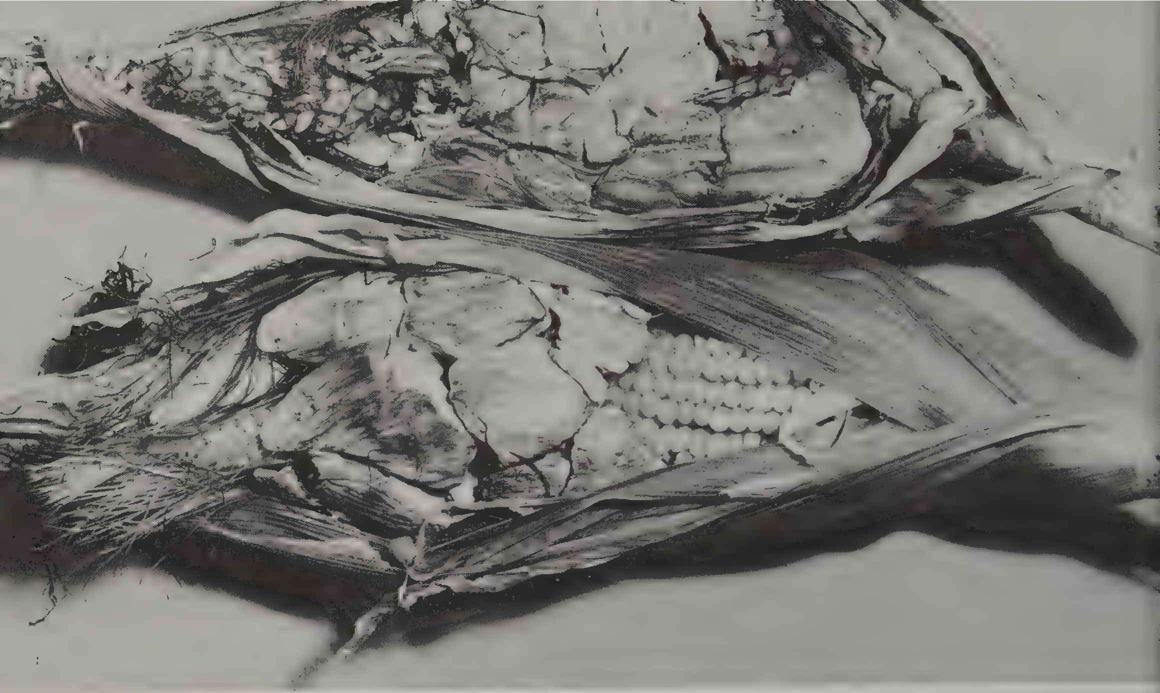
CROP VARIETIES RESISTANT TO INSECTS

In a cooperative project with the forage section, the tolerance of alfalfa clones selected for resistance to the spotted alfalfa aphid in the greenhouse at El Horno was confirmed in the field at La Cal Grande this spring. Only two clones of the 90 represented were found to support aphid reproduction, while large populations of aphids were seriously damaging nearby commercial fields. Seed from these clones will be used in the development of a commercial alfalfa variety resistant to aphid attack.

In a cooperative project with the corn section, some 65 representatives of the principal native races and collections of corn in the Mexican breeding program were planted at CIANO, in both the spring and summer, for observations on their susceptibility to thrips, *F. occidentalis*, budworm, *L. frugiperda*, and stalk borer, *Zeadiatraea grandiosella* (Dyar). Four collections exhibited definite tolerance to thrip attack: Zapalote Chico, Zapalote Grande, Comiteco, and Nuevo León 17. Data taken on budworm and stalk borer were inconclusive owing to the variability of the insect populations. Increasing emphasis is now being given to laboratory techniques in resistance screening work in an attempt to avoid the problem of uneven insect population distribution in the field.

MISCELLANEOUS STUDIES

In a cooperative project with the plant pathology section at El Horno, the influence of grain moisture content, temperature, and weevil infestation upon fungus development in corn was studied in small experimental silos each containing approximately 230 kg. of grain. During this five-month study it was found that maximum moisture content was maintained in the lower third of the grain mass where lowest temperatures were recorded. The fungi present, principally *Aspergillus glaucus* and *A. restrictus*, exhibited maximum development in grain that maintained a moisture content above 13%, while little fungus development occurred below this moisture level. The presence of the granary weevil, *Sitophilus granarius* (L.), did not appear to influence the spread of fungi through the grain in this study.



Ears attacked by horse's tooth, a new disease of corn in central Mexico.

Plant Pathology

During the period covered by this report, studies were continued on fungi of stored grains and head smut of corn, a disease that is prevalent in the Bajío. Other work included tests of fungicides for the control of damping-off of cotton, research on the stunt virus and *Helminthosporium* of corn and on foliar diseases of tomato, as well as basic studies on members of the genus *Phytophthora*, especially *P. infestans*. A new corn disease, referred to locally as "horse's tooth," has been discovered in the cool highlands of central Mexico.

FUNGI OF STORED GRAINS

With the increased production of grains in Mexico during the past few years, correspondingly greater quantities of these grains are being stored for longer periods of time, and there is thus greater opportunity for damage by fungi. Losses have been especially severe in the storage of corn, barley, and beans. Little precise information has been available on the amount of these losses and on the fungi that cause them. Recent data obtained by the phytopathology section have, however, awakened wide interest in this problem and in the search for practical methods of solving it, such as inexpensive procedures in the management and handling of grain.

The importance of fungi in the deterioration of stored grain was repeatedly demonstrated in studies made during the past year. Over 100 samples of corn, representing more than 2,000,000 tons of grain, were examined. These came from many different parts of the country and were therefore indicative of the condition of the corn in storage in Mexico. Nearly 50% of the samples, representing more than 200,000 tons of grain, were so badly damaged by storage fungi that they were suitable only for livestock feed. The embryo of the seed was discolored and had been invaded by several stored grain fungi.

About 100 samples of barley, representing over 50,000 tons of barley for malting, were examined. About 40% of the samples, representing over 15,000 tons of barley, had deteriorated to the point where their germination was too low for malting purposes, and in some instances even their value for livestock feed was questionable. This represented a great loss to the owners of this stored grain and to the malting companies.

In the case of wheat, few samples showed any damage from stored grain fungi, probably because a great part of the wheat production in Mexico is in the Northwest, where wheat is harvested and stored under very dry conditions and at a low moisture content.

Although comparatively few samples of beans were studied, indications are that stored grain fungi are very important in the reduction of germinability of the bean, especially in storage in the tropics. This phase of the work needs more sampling and study.

In the majority of the above-mentioned cases of grain storage losses, the samples were relatively free of insects, and damage was thus due almost entirely to fungi. While these data are not intended to minimize the importance of insects in the storage of grain, they do show that the importance of fungi in stored grain losses has been greatly underestimated. *Aspergillus* is the most important genus of fungi attacking stored grain in Mexico, the principal species being *A. glaucus*, *A. ochraceus*, *A. candidus*, and *A. flavus*. Since each of these fungi requires a specific optimum moisture content of the grain for development, the presence of a given species is often a more exact indication than the moisture meter of the moisture content of the stored grain.

Maintenance of the moisture content below 13% is usually sufficient for good control of storage molds. This can be attained by drying the grain with mechanical driers or by sun-drying, before the grain is placed in storage. It is essential, however, that the moisture content be determined accurately. Studies of several moisture meters in commercial use in Mexico indicate that these are not sufficiently exact.

HORSE'S TOOTH DISEASE OF CORN

During the past year, an apparently new disease was discovered in fields of native corn grown at high, cool, humid locations in the States of México and Michoacán. Though only locally important, damage in individual fields may run as high as 30%. The disease is unreported from other parts of the world, but it has been present long enough in fields of farmers in certain areas to acquire the local name "diente de caballo," or "horse's tooth."

The outstanding symptom is a hypertrophy of the individual grains, caused by a fungus, that results in their growing into club-shaped structures, sometimes 3-4 inches long. Once a number of the grains are affected, the ear becomes swollen and deformed. The deformed grains are firm in consistency when first collected in the fall, and later become very hard. The pathogen has not yet been identified.

HEAD SMUT OF CORN

Head smut of corn (*Sphacelotheca reiliana*) is widespread in the Mesa Central and is recognized as a serious pathogen on several of the new hybrid corns. During the 1960 season the rains began very late in the Bajío and the incidence of head smut was somewhat lower

Head smut of corn, endemic in central Mexico, has become a serious problem in new hybrids.

than in previous years, although in some fields near Cortazar, Guanajuato, losses of 30-35% were observed, while in fields near Querétaro losses were as high as 60%.

Since 1959 studies have been made on the control of this pathogen through the development of resistant varieties and hybrids. In 1960, a number of races of corn were tested for resistance to *S. reiliana*. As shown in Table 1, the races from the higher altitudes tend to be more resistant, and those which prevail at lower elevations and along the coast more susceptible.

TABLE 1.

Reaction of Mexican corn races to head smut (*S. reiliana*). Cortazar, 1960.

Race	% plants with smut	Altitude of best adaptation (m.)
1. Dulce	1.5	1,000—1,500
2. Comiteco	2.1	1,000—1,500
3. Conico Toluca	3.1	2,200—2,800
4. Cacahuacintle	3.7	2,200—2,800
5. Conico Norteño	3.9	1,600—2,100
6. Palomero Toluqueño	5.1	2,200—2,800
7. Chalqueño	5.2	1,800—2,300
8. Arrocillo Amarillo	5.6	1,600—2,000
9. Tablancillo	5.6	0—1,500
10. Jala	5.7	0—1,000
11. Harinoso de Ocho	7.3	0—100
12. Bolita	7.3	900—1,500
13. Pepitilla	11.2	1,000—1,700
14. Celaya II	12.2	1,200—1,800
15. Reventador	16.7	0—1,500
16. Nal-Tel	17.6	0—100
17. Olotillo Blanco	19.4	300—700
18. Chapalote	23.2	100—600
19. Zapalote Grande	25.3	100—600
20. Zapalote Chico	29.1	0—100
21. Tuxpeño	32.0	0—500

Table 2 presents the data obtained in a trial of certain hybrids and varieties that are commonly grown in the Bajío, where the disease is prevalent.

TABLE 2.

Head smut on corn hybrids and varieties in the Bajío. Cortazar, 1960.

Hybrid or variety	% plants with smut	Resistance
Colorado de Apaseo	7.1	High
Criollo de Urquiza	11.1	Medium
Criollo de Cortazar	11.6	Medium
H-230	12.4	Medium
H-220	16.1	Medium
H-503	30.2	Low
H-352	31.8	Low
H-353	35.5	Low
VS-550	47.2	Low

To date, the native or criollo varieties have shown more resistance to head smut than have the hybrids developed for the region. The most resistant variety tested, Colorado de Apaseo, is thought to have some germ plasm of Cacahuacintle, but its exact ancestry is uncertain. The variety Criollo de Urquiza is a corn of the Conico Norteño type which, as shown in Table 1, is one of the more resistant races. As would be expected, the hybrids with Tuxpeño germ plasm, like H-353 and the tropical H-503, are very susceptible.

TABLE 3.

Effectiveness of five fungicides in controlling cotton damping-off on the variety Coker 124-B. Torreón, 1960.

Compound	Dosage per 100 kg. seed	% plants with damping-off
Rhizoctol	170 gm.	4.6
EP-126-A	780 gm.	7.9
PCNB	400 gm.	8.2
EP-125	720 gm.	8.4
Panogen	190 gm.	8.7
Check	—	15.7
L.S.D. (5%)		3.4

DAMPING-OFF OF COTTON

Recently, the damping-off disease of cotton has been increasing in prevalence and severity in the cotton-growing regions of Mexico. This disease is caused by the fungus *Rhizoctonia solani*, which persists in the soil and attacks the young seedlings just before or after they emerge. The losses are greatest when the weather is cool and wet at time of planting.

In 1960 an experiment was conducted in a farmer's field near Torreón to determine the comparative effectiveness of five compounds now commercially used by growers for the control of cotton damping-off. The results, presented in Table 3, indicated definite beneficial results from the application of all five fungicides to the seeds. Even more striking results might be expected in years of greater loss from this disease. This project will be continued in 1961 with a larger number of materials representing a greater range of chemical types.

Recording weight gains of turkeys grown on Ladino pasture.

Poultry

During the past year, the poultry industry in Mexico has undergone several changes heretofore unexperienced. The most important is the critical position of the poultryman, who has been caught between high production costs and the lowest egg prices paid to farmers in memory. High production costs are due to high overhead costs, inefficient utilization of labor, high feed costs, high mortality, and poor management. Mortality rates have risen in both the growing and laying periods, principally because of Newcastle disease, chronic respiratory disease, and associated infections; in addition, laryngotracheitis has become more widespread. These problems have resulted in the elimination of many marginal egg producers and also in a shift in areas of egg production.

Poor egg prices are due to no single economic factor but are rather the product of a complex marketing situation. The poultryman is extremely vulnerable to price manipulation because he is unorganized. As egg production has increased in various regions of the country, competition for metropolitan markets has increased sharply, with consequent glutting. A similar and perhaps more erratic situation exists in the broiler market. Unfortunately, the consumer has benefited little from this situation, for if he did, perhaps consumption would rise and thus alleviate the marketing problem.

With a view toward minimizing costs, the poultry section is giving particular emphasis to the study of less costly materials as sources of nutrients and to poultry disease studies. In addition, certain management problems are being re-evaluated.

POULTRY NUTRITION STUDIES

Although sorghum may be substituted directly for yellow corn in poultry diets, this grain is poor in xanthophyll content and when used in poultry rations results in pale skin and yolk color. The corn section has been working recently with a variety of sorghum which has a yellow endosperm. In an experiment to determine its value in producing yellow pigment in the skin of broilers, it was found that this grain compares poorly with yellow corn and is not much better than white sorghums.

Rice polishings, a subproduct of the rice milling industry resulting from the rice cleaning and polishing process, has not been used extensively in poultry diets in Mexico. An analysis of this product indicates, however, that it is a potentially good poultry feed ingredient: humidity 10%, protein 12.9%, crude fat 15.0%, crude fiber 6.8%, ash 7.9%, nitrogen-free extract 47.4%.

In an experiment in which 20% of rice polishings was used in a diet in place of corn, chick growth was only 88.9% of that obtained on a normal corn-soy diet. The fact that the rice feed consumption was considerably reduced may, however, explain the inferior growth. It is quite possible that because of its high oil content the rice polishings became rancid and resulted in a bad flavor of the feed.

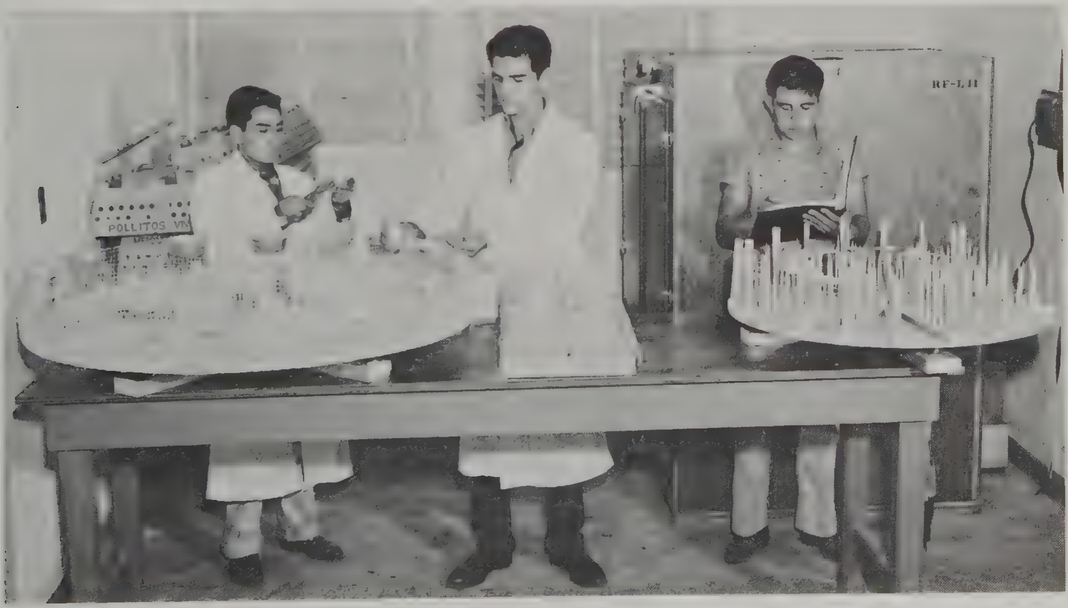
Although the nutritional value of barley is not equivalent to that of corn, wheat, or sorghum, various reports indicate that some barleys may be improved by the addition of fermentation enzymes. Results obtained during the past year indicate that the addition of 0.10% fungal enzyme preparation improves the nutritional value of barley in terms of chick growth and feed efficiency.

In a recent experiment on chick diets, the soybean oil meal component was replaced by yeast at different levels between 20% and 100%. Chick growth at all levels indicated that yeast can be used as a partial or complete substitute for soybean oil meal when the ration is properly balanced.

Poultry Management Studies

Many poultrymen purchase their baby chicks only at certain times of the year, while others buy theirs at any time. The performance of chickens varies, however, with the time of year when they were hatched. To determine the relationship between date of hatch and reproduction characteristics, three lots of chicks having the same genetic make-

A simplified system for banding chicks and recording pedigrees.



up but hatched on different dates were tested under tropical (Cotaxtla) and subtropical (Santa Elena) conditions. Although the data obtained did not indicate a consistent pattern in the differences in age at sexual maturity, two of the lots at Santa Elena showed earlier sexual maturity than the third. Egg production for corresponding lots was not different at the two stations, but there were differences between lots at the same location.

Because the percentage of hatchability declines with increasing altitude above sea level, commercial hatchery operations are located wherever possible at lower altitudes. Even where this can be arranged, however, the fertile egg supply flock may be located at a different altitude from the hatchery. To test the effect of fertile egg transfer from high to low altitudes and vice versa on subsequent hatchability, fertile eggs from genetically similar parental stock located at Santa Elena (2,500 m.) and Cotaxtla (15 m.) were incubated at both these stations. The data obtained show that fertility of hatching eggs can be equally as good from hens in the warm tropics at sea level as from hens in cooler regions at high altitudes. Statistical analysis of these data also indicates that eggs produced at different altitudes hatch equally well when incubated at the same altitude, although a slight advantage is apparent for eggs produced at low altitudes.

INVESTIGATIONS WITH TURKEYS

The turkey utilizes large quantities of good pasture, and when good forage is available it is recommended that turkeys be reared with access to the forage. In an experiment conducted at Santa Elena, various diets were used in combination with Ladino clover pasture during the growing period from 9 to 24 weeks.

The data obtained indicate that the best weights at 24 weeks were made by the turkeys on pasture with free access to corn and concentrate, either together or separately. The out-of-pocket feed cost per kilogram of gain was higher in confinement than in pasture.

Animal Pathology

Investigations in animal pathology have been expanded from principally diagnostic activities to include studies of certain specific infectious diseases of poultry and also the specialized field of bovine mastitis.

POULTRY DIAGNOSTIC LABORATORY

The poultry diagnostic laboratory, which is located at the Veterinary School of the National University of Mexico, has made excellent progress in delineating the existence and relative importance of the numerous diseases affecting the poultry in the region it serves.

During the year, an average of 42.3 cases per month entered this laboratory. Continual increase in the number of cases entering the laboratory demonstrates the general acceptance of this service. More important, however, than this increase is the fact that the laboratory has now observed what may be considered a representative sample of the occurrence of the more acute poultry diseases of the region.

Six disease entities not previously encountered by the poultry laboratory have been established as existing in Mexico. These are the infectious and contagious diseases: paracolon infection, infectious synovitis, staphylococcal arthritis of turkeys, infectious laryngotracheitis, and the little understood avian monocytosis and cage-layer fatigue. Infectious laryngotracheitis, a virus disease of chickens, was diagnosed in three closely adjoining poultry farms near Mexico City, and reported immediately to the Bureau of Animal Industry. Since Mexico had been considered free of this disease, an attempt is being made by the federal government to eradicate the disease through slaughter of all infected flocks of the area.

RESEARCH ON NEWCASTLE DISEASE

Newcastle disease continues to be the most dreaded and serious disease affecting poultry in Mexico. In itself it is responsible for annual losses to the Mexican poultry industry amounting to millions of pesos.

The principal problem in the Newcastle disease enzootic in Mexico is that vaccination, which is quite effective in many other parts of the world, does not confer good protection on poultry flocks here. Carefully conducted field investigations of flocks afflicted with Newcastle disease have failed to support the widely held opinion that inadequate immunity in these flocks is attributable either to faulty application procedures or to reduced vaccine potency due to poor management of these vaccines. Research efforts have therefore been directed toward a study of the immunizing capacities of commercial vaccines commonly used in Mexico.

According to the standards for Newcastle disease vaccine potency recommended by the United States National Research Council, a vaccine is considered acceptable if, under their standard experimental design, 90% of vaccinated chicks are immune to challenge with a standard dose of the Texas G.B. strain (the most virulent field strain in the United States) while 90% of the unvaccinated control birds succumb.

Using the suggested 90% protection criterion, an experiment was conducted to evaluate the relative potency of three commercial Newcastle disease vaccines and one experimental vaccine produced in the laboratory. The commercial vaccines tested were: the dead vaccine, California R.O. strain virus; live virus B_1 strain; and the Roakin virus strain. The experimental vaccine was a formalin-killed vaccine prepared from the Mexico University (M.U.) virus, which is considered to be the field virus responsible for the vaccination breaks in the Valley of Mexico.

The results of this experiment are shown in Figure 1. When the Texas G.B. virus was used as a challenge virus, all the vaccines except the California R.O. dead vaccine could be considered adequate according to the established standards of vaccine testing. When the challenge virus was the live and fully virulent M.U. strain, however, only the experimental formalin-killed vaccine prepared from this field strain provided adequate immunity in vaccinated birds. These results strongly suggest that the M.U. field virus is widely divergent immunologically from the commonly used commercial vaccine strains and that the latter can therefore not be considered acceptable.

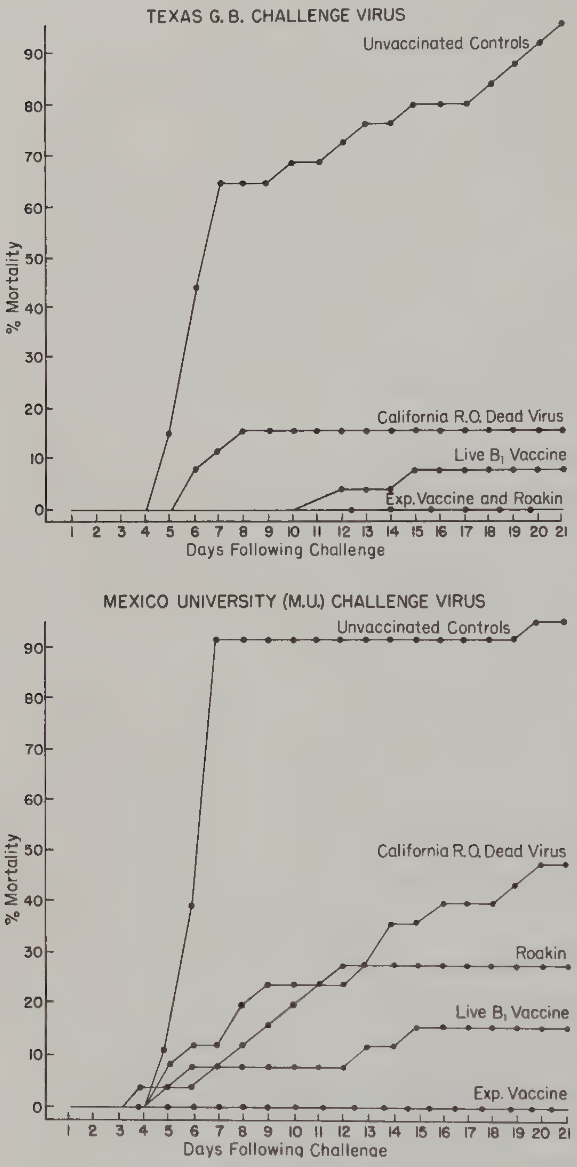


Figure 1. Mortality of chicks vaccinated against Newcastle disease with experimental and commercial vaccines when challenged with the Texas G.B. and Mexico University strains of Newcastle virus.

Further research is now in progress on the antigenic diversities of the M.U. strain of Newcastle disease virus and the possible commercial application of dead-virus vaccines produced from this strain.

RESEARCH ON BOVINE MASTITIS

Mastitis is the most important disease complex affecting dairy cows wherever dairying is practiced, and has been widely studied in many parts of the world. Where no organized attempts are made to control the disease, the bacterium *Streptococcus agalactiae* is universally the leading cause of mastitis. Where successful control programs have been started, however, milk production has been shown to rise by 10-20%. Mastitis caused by staphylococcal species is very common in parts of the world where milking machines are used. The relatively low incidence of this type of mastitis in Mexico, where hand milking is the usual practice, lends support to the often expressed opinion that traumatic damage from milking machines is the main predisposing factor in staphylococcal mastitis.

In the milk-shed area of Mexico City, dairying is an important and large-scale business. Because of the relatively high production costs, however, fresh whole milk ranks as a luxury food, and the less well-to-do people must depend on reconstituted dried milk imported by the government and sold at half the price of fresh whole milk. The problem confronting the dairy industry, therefore, is how to lower production costs in order to expand its market.

Studies were initiated by the animal pathology section to obtain data on the degree of severity of bovine mastitis in this area and the possibility of increasing production efficiency through control of the disease. The results of a bacteriological survey of a representative number of milk samples from 15 dairy herds showed that close to 85% of the cows were infected with *S. agalactiae* and that close to 5% were suffering from staphylococcal mastitis.

Control programs in other countries based on the bacteriological diagnosis and elimination of *S. agalactiae* from infected udders through antibiotic infusions have proven of great value in minimizing this disease and subsequently increasing milk production. The establishment of such a control program in Mexico has been considered impractical by many dairymen because of the difficulty of isolating infected cows from those free of the disease. In an experiment to determine whether progress could be made in controlling the disease without isolating the infected cows, it was found that an acceptable curation rate of 56.7% could be achieved but that the rate of new infections resulting from constant exposure to the organism was sufficiently high, 29.2%, to render the procedure impractical.

A study is now in progress to secure data on the degree of increase in milk production which can be expected when isolation of the infected cows is practiced. Concurrently, an economic evaluation of this procedure is being made to see if the additional costs involved can be offset by the increased production.

Market day at Tehuacán, Puebla.

Agricultural Economics

Investigation in agricultural economics is directed toward problems of agricultural resource allocation and final product distribution. Emphasis continues to be on farm production economics, but some work is also under way in agricultural marketing. This report summarizes two projects in which particular advances were made during the past year, one in the field of farm production and the other in marketing.

Economic Study of Ejidal Agriculture in the Yaqui Valley, Sonora

Although *ejidatarios* in the Yaqui Valley of Sonora are among the most favored in the entire Republic from the standpoint of land and water resources, available credit facilities, and general level of technology, their standard of living is not commensurately high.

This study was initiated because the favorable set of resources and other production conditions suggest real potential for improvements in production as well as in the material well-being of this large group of farm people. The specific objectives of the study are:

(1) To describe the method and organization of both collective and individual *ejidal* farm operations.

(2). To determine the efficiency in the use of resources available, considering the physical, institutional, technological and economic scale factors, in order to study more optimal combinations of factors.

(3) To evaluate managerial and organizational changes that might increase the effectiveness of these *ejidal* agricultural operations within the framework of existing institutional arrangements.

In order to fulfill these objectives, it was necessary to interview a representative sample of *ejidatarios* who individually operate their parcels of land and to make a complete enumeration of the collective *ejidal* farms. A total of

240 *ejidatarios* were interviewed and information obtained describing their farm businesses for the 1958 crop year. A stratified random sampling procedure was used. In addition, accounting records were reviewed and summarized on the 14 collective farms and personal interviews were held with the administrative committees of these collective societies. This brief report will review only the results of the individual farming units.

Table 1 gives descriptive data on the general structure of the individual *ejidal* farming units in the Yaqui Valley. One of the most significant features of the *ejidal* parcel in this valley is that it averages almost 18 hectares of irrigated crop land. Such a generous endowment of land and water resources was more nearly an accident of history than a case of foreplanning. When the agrarian reform took place in this zone, the dotations were approximately 8 hectares of irrigated land per person benefited plus variable extensions of desert brush land. At a later date the irrigation system was extended and much of the *ejidal* brush land was transferred into irrigated crop land.

Among the 240 *ejidatarios* interviewed, only about one out of three had vehicles, about one out of five had a tractor, and none had a grain combine. Livestock enterprises were quite uncommon, most of the existing livestock production being for home use.

The *ejidatario* dedicated only about half his time to the parcel. He usually had some help from family members but in general employed more months of outside labor than were worked by himself and his family.

For this group of *ejidatarios*, as throughout the zone, crops were principally cotton and wheat. Crop yields obtained on *ejidal* farms for the study year were comparable to those obtained on farms in the private sector. The very low corn yields from the 1958 fall planting were due to a cyclone during the growing season that severely damaged plantings.

TABLE 1.

Description of farm structure for *ejidatarios* with individual exploitation. Yaqui Valley, 1958.

Concept	Quantity
Land resources:	
Crop land (hectares)	18
Capital resources (average inventory in pesos):	
Livestock	2,100
Machinery and equipment	13,400
Buildings, etc.	1,600
Total	17,100
Labor resources in man-months:	
Ejidatario	6
Family labor	3
Day and migrant	13
Total	22
Land use (hectares planted):	
Cotton	5
Wheat	9
Corn (1958 fall planting)	3
Other crops	1
Crop yields:	
Cotton (Kg. seed cotton/ha.)	1,900
Wheat (Kg./ha.)	2,200
Corn (Kg./ha.)	1,000

Table 2 gives a summary of the financial results obtained on the farms included in this study. The "net income" figure reflects the amount of money which the *ejidatario* had for his family living expenses and for reinvestment in his farm business. In order to get a more adequate measure of farming effectiveness, estimated charges have been made against the net income for changes in inventories and for unpaid family labor. The resultant "farm income" gives a better idea of what the combination of resources directly controlled by the farmer really produced; in this case, about 6,700 pesos. This is the value of products produced by the *ejidatario* with his land, capital, and labor. If a differential rent charge is subtracted from this quantity along with an interest charge on the capital invested, the resulting "labor income" is what the *ejidatario* received for his contribution as a laborer and manager. The result is a negative 3,800 pesos.

TABLE 2.

Income summary for *ejidal* farms with individual exploitation. Yaqui Valley, 1958.

Concept	Quantity (pesos)
Cash receipts	31,700
Cash costs	23,100
NET INCOME	8,600
Change in inventories	− 700
Family labor charge	1,200
FARM INCOME	6,700
Differential rent	9,000
Interest charge on farm capital	1,500
EJIDATARIO'S LABOR INCOME	−3,800

In reality, the *ejidatario* in this region is accepting a negative income from his labor efforts for the privilege of managing his farm. Since, as noted above, these farmers have quite satisfactory land and water resources, employ good production techniques in order to obtain high crop yields and have credit readily available, it becomes obvious that there are serious problems of an organizational nature.

One of the most serious is the failure of this group of farmers to take an active part in their farming businesses. The extent of this problem may be appreciated from the data in Table 3 on the amount of available family labor and the uses that were made of this labor supply. Only half the amount of family labor available was directly dedicated to the farming parcel. It must be remembered that while there is under-employment of family members, considerable outside labor was employed. Even more serious is the fact that only about one-fifth of the time nominally dedicated to the parcel was actually spent on productive endeavors. Thus, over 70% of the time of the *ejidatario* and of his family was not productive.

It would appear that among this group of *ejidatarios* in the Yaqui Valley, too much attention has been given to production per area of land and too little to the utilization of the human factor. Because it has been relatively easy to apply a high level of technology on *ejidal* lands by the use of extensive agricultural credit and the hiring of special services, the *ejidatario* has lost the advantages of direct involvement in his own farming business. It is not to be expected that farming would be so profitable as to justify the hope of receiving a satisfactory income without a bigger contribution to the management and production processes.

These are problems which cannot be readily solved by the *ejidatarios* themselves. Their limited participation in the business of farming is in large part determined by a series of well-established institutional arrangements beyond their direct control. The following are some of the more important production parameters:

(1) The administration of the irrigation system and of the public credit banks determines in large part which crops shall be grown during a particular growing season. Water and credit are made available only for particular crops; the *ejidatario* has little choice in deciding what crops he will grow in a particular year because he is completely dependent on these agencies. His management contribution on the important question of which crops to grow is minimal, yet he is the one who knows best the special characteristics of his farm resources.

(2) Public credit is made available to this group of farmers on the basis of agricultural operations accomplished. The standard machine-hire rates are authorized for each farming operation and payments are made when the plowing or disking or other operation is finished. When credit is extended on this basis, there is little contribution toward the construction of farm capital. There is also little motivation for saving and reinvestment in the farm business.

(3) The extension of credit is through cooperative credit societies. Since the members of the society lack machinery and equipment with which to work their lands, they tend to agree to plant the same crops in contiguous plots in order to simplify the letting of custom

work contracts. They also tend not to permit members to engage in higher risk activities because of mutual repayment responsibility.

(4) The size of the tractors and machines in general use throughout the valley is much too large for a typical *ejidal* parcel. The purchase of a large-sized machine unit would be anti-economic and the hiring of machine service allows very little active participation of the *ejidatario* in the farming operation. Up to the present, little thought has been given to the introduction of smaller-sized machine units that would be balanced with the needs of the parcel and would permit full productive employment of the *ejidatario* and his family.

There can be little doubt that substantial opportunities exist for better farm organization on these farming units and for a proportionally higher standard of living for the *ejidatarios* and their families. This study is being continued with an evaluation of alternative farming systems by calculating budgets for different rotations and for different tenure relationships. The possibilities for the acceptance of more profitable farming systems will be influenced by the parameters given by existing institutions.

THE TEHUACAN REGIONAL MARKET

More than half the Mexican population depends on local markets for the basic elements in their daily diet. From the central part of the country on to the south, housewives outside of the larger cities depend almost exclusively on the local market as the source of food for family meals. The simplest possible system of marketing is carried out in the plaza. During the week, small merchants who have direct contact with producers sell to housewives. They know what the housewife wants in the

TABLE 3.

Family labor supply and the uses to which it was put by all *ejidatarios* with individual operation. Yaqui Valley, 1958.

	MONTHS:				
Class of workers	Potential labor	Dedicated to parcel	Actual labor on parcel	Off-farm labor	Unemployed
Ejidatario	28,000	14,500	3,100	5,700	7,800
Sons	13,300	7,000	1,500	1,700	4,600
Other family	3,900	1,500	300	600	1,800
Total	45,200	23,000	4,900	8,000	14,200

Summary of actual use of family labor supply:

	Man-Months	%
TIME NOT PRODUCTIVE		
Idle time dedicated to the parcel	18,100	40
Not employed	14,200	31
	(32,300)	(71)
PRODUCTIVE TIME		
Actually worked on the parcel	4,900	11
Off-farm employment	8,000	18
	(12,900)	(29)
TOTAL	45,200	100

way of food products and what she is willing to pay. The small merchant can relay this information directly to producers, or he may himself be a producer. Two of the biggest marketing problems, those related to keeping abreast of change in demand and those of reflecting consumers' demands to producers, are resolved on the basis of direct contact with both consumers and producers.

This simple marketing system has existed for generations, with only minor adjustments. To be sure, in some regions prehistoric methods of barter continue to be employed. In other regions, bulk measures are used rather than systems of weight, because volume quantities are better understood and both parties therefore feel more confident of defending themselves in the exchange process. A satisfactory knowledge of just how a traditional regional market functions is basic to a careful consideration of the types of services which must be developed as a region leaves behind its traditional patterns of agriculture and begins to respond to the most recent technological developments.

In part, the general objective of this study of the Tehuacán regional market is descriptive: Where do the products come from; how are they handled; what are the interrelations between the various areas of the region served; how efficiently are the products moved; and what kinds of potential improvements are feasible under present conditions? The study is also serving, however, to provide experience in market investigation.

The region served by the Tehuacán market was delineated by determining the degree to which this city intervened directly in the commercial activities of the *municipio* concerned. A total of 72 municipios of the States of Puebla and Oaxaca surrounding the City of Tehuacán are included in the region. There are approximately 10,000 square kilometers of area in the zone and the population may be estimated at about 300,000 persons. It is well accepted that the Tehuacán region is still a highly tradition-oriented part of Mexico. It has a minimum of commercial relations with outside areas and has been slow to adopt modern technology. Although satisfactory data are not available, the general observation may be made that the area supplies most of the corn, beans, and chile consumed. Some corn deficit may be purchased by the sale of tomatoes, wheat, and palm products to outside areas and of course there are commercial activities outside agriculture.

The Tehuacán regional market consists of the central plaza in the City of Tehuacán and eight secondary plazas in towns surrounding the city. In addition to these more important commercial centers, there are smaller-scale activities in the villages and in rural areas. Saturday is the principal market day in Tehuacán. On this day people from throughout the region come to sell their products in the plaza of Tehuacán and, usually, to buy different products which they can take back to their own villages. While during the week there may be between 250 and 300 stands with agricultural products, on Saturday the number increases to over 1,000. In the Tehuacán plaza exchange takes place and the basic elements of a market exist in that the price-determining forces fix a price that enables the quantity offered for sale to balance the quantity for which buyers are willing to pay.

The surrounding secondary markets form a system in coordination with the principal plaza in the sense that merchants who normally trade in the secondary markets can assemble surplus products from their areas during the week in preparation for the Saturday market and exchange them for products that are in deficit supply in other areas.

While it is true that the Saturday market plays a determinant role in servicing the region, the fundamental structure of the market is formed by a group of merchants who have well-established stands and who sell products during the week as well as on market day. A sample group of these merchants was interviewed in order to get information which would help to describe the function of one of the important groups that intervene in the marketing process.

There is a complete range in size of business enterprise in the main plaza, from the merchant who has a total inventory of 20 pesos and one product to those with inventories of several thousands of pesos and a wide assortment of products. One of the most important measures of merchandising efficiency is the value of product sold per unit of labor. For the most part the merchants work alone in their stands. About one-third, however, did have someone helping, in most cases a family member. The average daily gross sales were approximately 30 pesos. Only about one-third of this quantity would be net, because the merchants must either buy the products they are selling or meet the costs of production.

The average merchant in the Tehuacán market is producing only about 7 pesos per day of locational utility in the marketing process. It is perfectly obvious that many fewer people could handle the total amount of sales that originate in the plaza. It is, however, to be expected that the present type of marketing arrangements will continue until the region develops more attractive alternatives for those who currently sell in the market. Until wages generally rise in the area, there will be no tendency to increase the volume of sales per sales-person.

The productivity per person in the secondary plazas and in the Saturday market in Tehuacán is even lower than that in the established stands during the week in Tehuacán. Here, once again, the lack of alternative, higher paying employment eliminates economic incentive for concentrating products in fewer hands. There is little reason to think that prices to consumers are kept abnormally high by the large number of sellers relative to the quantity of product; no monopolistic power exists, the marketing channels are minimal, and consumers have as much economic strength as do the marketing firms.

In addition to the lack of economic incentive for more efficient marketing processes, there are strong cultural and social forces tending to maintain the *status quo*. The Tehuacán region includes much of the *Mixteca Alta* and women in this cultural group have strong customs and traditions regarding market activities; it is women's activity to take products to the market and return with goods for the family's use. The social participation of spending the day at the market is also important; market day is the highlight of an otherwise dull existence.

But not all commercial activity is channeled through the formally established market system. Those products which are leaving the market area tend to be handled through other channels. In the main city, a few bigger merchants have established stores with a selection of hard-goods not readily found in the central market. They often extend credit to producers and they buy grains either for storage and later sale or on contract for processing plants in cities outside the local market region.

In addition to these dealers in grain, trucker-dealers may purchase surplus perishables such as tomatoes and fresh ear corn for *elotes* for haulage into Mexico City where a wider market exists for such products.

The activities of these two groups are examples of arrangements which develop because the older established institutions have been unable to handle newer situations. The grain dealers and hard-goods merchants established businesses long ago, undoubtedly because the large capital needs of this type of business were beyond the capacity of small merchants. The trucker-dealer, on the other hand, is a more recent addition to the area marketing system. In this instance, technical knowledge of the product—how to move it between two points, how to prevent damage and loss of value in transit, and how to sell it in a metropolitan center—creates a new dimension of the marketing problem. A group of men developed who had this technical knowledge.

The Tehuacán region is still a tradition-oriented agricultural region. There are few forces in the zone tending to break down this traditional orientation and it is doubtful that the participants in the marketing system will initiate change. The market as the expression of economic incentive, however, must be able to accommodate and encourage the introduction of modern technology to the region.

During the dry months farmers study bulletins and plan for the next season.

Agricultural Information

The prompt diffusion of research results, a policy well established by the Office of Special Studies, continues to be the policy of the new National Institute of Agricultural Research (INIA). A Department of Technical Information has been included in the new organization and charged with diffusing research results so that they may serve as a stimulus to other research workers as well as to the extension agents and farmers directly concerned with increasing food production. To carry forward this program the central office will continue to maintain a staff of persons specialized in various facets of information. In addition, there will be one agronomist responsible for extending research results at each of the major regional centers. These regional information specialists will work closely with the central office in producing written and visual materials for farmers, and at the same time will maintain close contact with all private and governmental agencies working directly with farmers in their regions.

PUBLICATIONS

One of the first decisions taken by the directors of the new Institute was to establish a Publications Committee. This committee was given the specific task of reviewing scientific manuscripts and the broader responsibility of establishing policy for the release of research results.

After a careful review of the existing series of publications, in both of the parent organizations of the new Institute, it was decided unanimously to continue the series which had been established over the years by the Office of Special Studies. In the list of publications at the end of this report, the numbering therefore continues consecutively, even though publications issued since January 1, 1961, appear under sponsorship of the new Institute.

RESEARCH REPORTS

During the year, six numbers were added to the *Folleto Técnico* series and one to the *Folleto*

Misceláneo series, bringing the totals to 43 and 11, respectively. Both series contain specialized information for teachers and research workers in agriculture and animal husbandry. In addition, 35 articles presenting recent advances in the field of agricultural research were published in the semi-annual journal, *Agricultura Técnica en México*.

The annual report to the Minister of Agriculture, edited and published in Spanish by this department, continues to provide a valuable source of reference for libraries and agronomists in Mexico and other Latin American countries.

Other important technical information was provided through the publication of the proceedings of the sixth annual meeting of the Central American Corn Improvement Program.

BULLETINS FOR FARMERS

With the growth of regional research centers, it has become possible to make more specific recommendations of adapted varieties and improved cultural practices for the production of various crops.

To give wider circulation to these recommendations, the publications series of the regional centers have been augmented. During the past year two new titles appeared in the Cotaxtla series, five in the El Horno series, three in the La Campana series, and four in the CIANO series. These circulars take into account the special problems of the region and employ vocabulary well understood by local farmers.

The publication of the Extension bulletin series was continued by the Director General for Agriculture and six new manuscripts by staff members of the INIA were published. In addition, 12 earlier bulletins were reprinted. During the year more than 100,000 copies of these publications were distributed to interested farmers by Extension agents.

Seven articles on horticultural crops and a double volume on the control of insects and diseases, were published in the quarterly *Novedades Hortícolas* series.

DISTRIBUTION

Publications for farmers are distributed largely through agronomists of the INIA and of the federal Extension Service. Research reports are distributed through a carefully maintained mailing list and in reply to direct requests. At present, the mailing list includes 2,300 addresses of experiment stations, colleges of agriculture, libraries, and agronomists and other professional men who have a serious interest in agricultural research. About 1,500 of these addresses are in Mexico, the other 800 representing 55 different countries in the Americas, Europe, Asia, Africa, and Oceania.

PRESS, RADIO, AND TELEVISION

The farmer bulletins are often reproduced partially or completely in newspapers and farm magazines. In other cases they provide the basis for more extensive articles. All of the farm magazines and national newspapers, as well as many regional and local papers, have used information from the Institute during the past year, many of them frequently, thereby giving a broad distribution to research results and recommendations. In all cases this collaboration has been one of mutual benefit in which the Institute provides the information and illustrations and the farm press provides the printed space and free distribution.

The farmer bulletins also furnish information for many farm radio programs, among them the *Voces del Campo* series, broadcast by Extension agents in most of the states of the Republic.

Information from the research program has also been transmitted to a wider audience through cooperation with television stations. Many films have been loaned for projection on farm programs and several interviews have been arranged with research and administrative personnel.

AGRICULTURAL FILMS

Recommendations based on research results are presented pictorially, and with a certain

Shooting the film on grass silage at Cotaxtla.

amount of drama, through the production of 16 mm movies. These films are produced in cooperation with the Extension Service.

PRODUCTION

Three new titles were added during the year, bringing the total to 13. The new films are as follows:

"*Tarétaro*" (The Place of the Planting), a true story of what happened to a Tarascan mountain family when they decided to try a new late-blight-resistant potato variety and at the same time to use adequate fertilization;

"*La Herencia del Ganadero*" (The Heritage of the Cattleman), which describes the different types of natural grasslands in the low-rainfall areas of northern Mexico and urges the ranchers to guard their heritage, the grazing lands for their cattle, by introducing better management practices; and

"*Forraje Ensilado: Alimento seguro en la época seca*" (Grass Silage: Sure source of feed during the dry season), which shows how the lush summer growth of grasses and legumes in the vast livestock-producing areas of the Gulf Tropics can be safely stored in a trench silo to provide nutritious feed throughout the annual drought period.

DISTRIBUTION

These films have been exhibited in small towns and large cities in most of Mexico's 29 states and 2 territories. Thousands of farmers have seen the films at regional, state, and national fairs. Many more have seen projections in their schools, *ejidos*, churches, public plazas, county buildings and at meetings of their farmers' or cattlemen's associations. In many cases, Extension agents use the films to lead off the discussion of a specific agricultural problem of local importance. Even when the films are used alone, they often trigger requests for seeds of new varieties, vegetative material of improved forages, and for more information. To satisfy the requests for additional facts, bulletins have now been published on most of the subjects covered by movies and are distributed to interested farmers at the conclusion of the projections.

Many organizations working in rural development are using these films, among them the National Indian Institute, the Secretariat of Public Education, the Department of Colonization, the Secretariat of Foreign Relations, and the Extension Service of the State of México. The eight mobile units of the federal Extension Service alone projected the films for some 130,000 farmers during the year.

Since the start of this movie program, messages of improved agricultural practices have been carried by film to some 500,000 farmers.

FIELD DAYS

Once or twice each year farmers and cattlemen of each region are invited to a special demonstration day at the experiment station. In this way they are able to see with their own eyes the progress being achieved in research on the principal problems of the region.

When the research workers at a regional station decide to have a field day for farmers, the information department works closely with them in organizing and publicizing the event. Personal invitations by circular letter are sent to all farmers who have attended previous field days; announcements are printed in the newspapers and broadcast by radio and television; posters are distributed through Extension agents, banks, credit unions and commercial houses; and many persons are invited personally. The result has been a continued increase in attendance.

Six field days were held during the year:

Field day for:	Place	Date	Attendance
Cattlemen	La Campana	Aug. 10, 1960	500
Farmers	El Horno	Sept. 9, 1960	1,400
Cattlemen	Cotaxtla	Oct. 18, 1960	850
Farmers	Cotaxtla	Oct. 21, 1960	1,600
Farmers	CIANO	Apr. 5, 1961	1,580
Cattlemen	Cotaxtla	Apr. 28, 1961	500

Contact is established with many new farmers each year through these field days. Many of them come back year after year, and often several times during the year, to consult with agronomists about specific problems. The agronomists, in turn, make use of these contacts to establish off-station field trials of experimental material.

AGRICULTURAL FAIRS

Although fair visitors often do not take time to study exhibits carefully, a certain amount of information can be presented to a large number of people through participation in these events. For this reason, informative material was presented in 13 different expositions during the year.

Personnel of the department took an active part in preparing the stand and mounting the exhibit, or in the projection of films, at eight fairs held in the States of Veracruz, Chihuahua, Tabasco, and San Luis Potosí. At the other fairs, held in Nayarit, Puebla, Hidalgo, Guanajuato, and Aguascalientes, illustrative material (seed samples, publications, graphs and photos) was loaned to those in charge of the event.

PHOTOGRAPHIC LABORATORY

The photographic laboratory provides services to the INIA, the Federal Extension Service, and the Rockefeller Foundation programs. Two well-qualified staff photographers travel extensively, visiting research stations and field experiments to take the photos needed to illustrate the various technical and popular publications.

A central file is maintained of all negatives, and the pertinent data on each one are recorded. Several of these negatives have been enlarged to make photographic murals and large positive transparencies for display in illuminated boxes at field days and agricultural expositions.

In the studio, one day a week is set aside for copying the graphs, charts, and maps used to illustrate reports and bulletins or made into slides for projection at scientific meetings.

There has been a large increase in the service requested of the laboratory during the past year; in 1959 work orders totaled 461 and in 1960, 620.

ART WORK

The department maintains one part-time and two full-time artists to handle illustrative work. During the year they gave attractive presentation to all of the bulletins and magazine articles published, and in addition prepared some 60 drawings, 42 graphs, 15 posters, 18 maps, and 12 cover designs. They also produced titles and simple animation for three educational films.

DIFFUSION OF INFORMATION FROM THE REGIONAL CENTERS

In order to make research results available more quickly and completely to farmers of the region, a pilot information program was established four years ago at the Cotaxtla station. This has succeeded so well that it is now planned to assign an information specialist to each of the other major centers as soon as enough trained personnel are available.

The following brief report describes some of the progress achieved at Cotaxtla during the past year.

FARM PAGE IN EL DICTAMEN

This page, which completed four years of weekly service to Veracruz farmers in the summer of 1961, continues to have the full support of the newspaper as well as the constant interest of the farmers and livestock growers of the region. Included in each issue are an interview with a successful farmer or agronomist, an article of recommendations based directly on research, a general article on some subject of agricultural importance for the region, a resumé of a new farmers' publication, interesting notes related to the agriculture of the region, and a section devoted to answering farmers' questions.

Some idea of the impact of the page may be gained from the facts that (1) other newspapers and specialized publications have asked permission to reproduce series of articles from the page; (2) many of the letters received daily at Cotaxtla asking for seeds or information on farming practices, refer to the farm page; (3) announcements of new bulletins in the farm page always result in numerous requests; (4) advertisers of agricultural products now insist that their advertisements appear on the farm page; (5) sales of the Thursday issue of *El Dictamen*, which carries the farm page, are now much larger than those of other week-day issues.

DEMONSTRATIONS WITH FARMERS

Although a large number of farmers and cattlemen are contacted each year through field days at Cotaxtla, many of the recommended practices are more convincing when demonstrated on a farmer's own land or that of a neighbor. During the 1960 growing season, some 30 farm demonstrations of corn, beans, and sesame were established.

The corn demonstrations compared improved and native varieties, with and without the application of fertilizer and insecticides. Similar comparisons were made in the bean demonstrations, except that insect control was practiced in all cases. These demonstrations attracted many neighboring farmers, especially at planting and harvest time. In many cases they requested more information about improved seeds and the other practices which were demonstrated.

The most complex demonstration, and perhaps the one of most potential importance for the Gulf Tropics, involved better grain storage and improved land utilization. Many farmers in this area grow only one crop per year, generally corn, but set aside some land on which beans or sweet potatoes can be planted at the end of the rainy season, using the residual moisture in the soil. Although the corn crop is mature before the beans or sweet potatoes are planted, the plants are doubled over to avoid wind damage and the ears left on the stalks to dry thoroughly before harvesting in November or December. Nothing more is done with this land until planting time the following June.

On the two farms participating in the demonstration, the corn was harvested with a grain moisture content of about 30% at the end of September, when the corn plants would usually have been doubled, and immediately stored in a low-cost crib built of palm, bamboo and woven wire, where it dried without fungus damage. To reduce the attack of stored grain insects in the crib, previously tested insecticides were applied. As a result, the damage by these insects was much less than it would have been in the field, damage by livestock was avoided, and it was possible to store some of the grain for a longer period and sell it later for a better price.

As soon as the corn was harvested, the corn stalks were gathered and a portion of the parcel was plowed and planted—to beans in one case and to sweet potatoes in the other. Fertilization and modern methods of weed and insect control were used, and good yields were achieved on both farms.

AGRICULTURAL FAIRS

With help on artwork from the central office, the technicians at Cotaxtla prepared complete exhibits for five important fairs in the State of Veracruz.

PILOT PROJECT AT EL MANGAL

Three years ago a modest development program was initiated in the *ejido* El Mangal to determine what changes in farming practices could be achieved in this type of farming community through the introduction of advisory services. During the past year, the demonstrations with individual *ejidatarios* were continued. A good deal of attention was also given to the school, both because of its educational importance and because (1) it is the only social institution, apart from the *ejido* itself, in which all of the families participate to some degree, (2) the school parcel, equal in size to an individual *ejidatario's* holding, is farmed cooperatively by all of the families and therefore makes an ideal demonstration ground, and (3) the school building provides a convenient meeting place for other constructive groups.

A full-time teacher has been obtained, who is now instructing nearly all of the school-age children as well as holding afternoon literacy classes for a group of parents.

Research on Information Methods

The research projects being carried out in this field provide the basis for a continued improvement in the information activities of the department. At the same time these studies contribute to the general knowledge of problems related to the diffusion of information and the adoption of improved farming practices. In addition to the project at El Mangal, the following studies are in progress:

(1) A study in the Bajío area to determine the influence of different sources of information on the acceptance of improved farming practices.

(2) A survey of the information media available in northwest Mexico and a study of their use by farmers of the Yaqui Valley.

(3) Delineation of procedures involved in the planning and production of educational films for rural audiences.

(4) An evaluation of the journal *Agricultura Técnica en México* as a medium for communicating scientific information to a professional audience.

Young agronomists consult scientific serials in the central library.

The Library

The library continues to play an integral part in the development of the cooperative agricultural research program in Mexico by providing scientific material, bibliographic information, microfilm service, and technical librarianship. With the formation of the National Institute of Agricultural Research in January, 1961, book and periodical usage and attendance in the library have increased almost twofold in comparison with last year. Every effort is being made to strengthen the libraries established at the regional centers of investigation. As facilities permit and as research projects progress, new books and journals are being procured and existing journal series are being completed.

THE COLLECTION

At present the central library in Mexico City contains a total of 10,236 bound volumes, of which 5,179 are textbooks, monographs, and reference material, and the remainder journals. In addition, 210 bound volumes of monographs and collected works, as well as 352 different publications prepared by the U. S. Department of Agriculture, have been acquired. Also on file are 1,742 U. S. agricultural experiment station publications.

TECHNICAL SERVICES

All new acquisitions are processed and controlled through the central library. During the period covered by this report, of 1,010 items received 344 textbooks, monographs, and reference works were placed in the library of the CIANO station and 353 items were added to the library at Cotaxtla. Both of these large disbursements consisted principally of items duplicated in the central library. The remaining 313 new acquisitions were placed in the central library. Bibliographic material composed of FAO agricultural publications, books dealing with animal husbandry, and professional theses were also acquired. It has been the policy of the library to obtain for reference purposes copies of professional theses presented by students at

Mexican schools of agriculture. During the past year, theses were received from the National School of Agriculture at Chapingo, the Superior School of Agriculture "Antonio Narro" in Saltillo, the Technological Institute of Advanced Studies in Monterrey, and the National University of Mexico, as well as from American universities.

SCIENTIFIC SERIALS

The central library now has a collection of 488 periodicals, many of which are complete from date of first issue. Of these, 275 are currently being obtained by subscription and 61 are being acquired either as donations or on an exchange basis. The remainder represent periodicals which are no longer being published.

The fact that the journals obtained through subscription total 65 more than last year indicates the effort being made to maintain and improve the service of the reference library. Among the new additions are nine Russian journals dealing with agricultural topics which have been translated into English by the American Institute of Biological Sciences and certain British institutions. The library is also receiving most of the important journals in the field of animal husbandry, and has a collection unique in Mexico. In 1961, the Mexican Society of Entomology donated their serial collection to the National Institute of Agricultural Research for inclusion in the central library.

At present, the libraries at Cotaxtla and CIANO are receiving 53 and 37 journals, respectively.

USE OF THE LIBRARY

The following statistics show clearly the notable increase in use of the library during the past year:

	1959-60	1960-61
Books taken out	473	839
Books used in the library	917	1,673
Periodicals taken out	239	462
Periodicals used in the library	1,306	2,572
Reprints taken out	58	964
Reprints used in the library	461	1,934
Miscellaneous publications taken out	126	270
Miscellaneous publications used in the library	701	1,142
Consultations	216	421
Attendance	3,666	6,144

OTHER LIBRARY ACTIVITIES

The librarian visited the six schools of agriculture in the Republic and the library of the National School of Veterinary Medicine, to study the facilities available for agricultural education and research. The object of this visit was to evaluate the present facilities and aid wherever possible in organizational matters.

Colombian Agricultural Program

Personnel

COLOMBIAN AGRICULTURAL PROGRAM

MINISTRY OF AGRICULTURE

His Excellency, **Dr. Otto Morales Benitez,** Minister of Agriculture
Daniel Mesa Bernal, ING. AGR., Director General
Joaquin Vanin Tello, Secretary General
Roberto Astrálaga di Ruggiero, ING. AGR., Head, Technical Section
Aníbal Duque Vélez, Administrative Secretary

DIVISION OF AGRICULTURAL RESEARCH
(DIVISION DE INVESTIGACIONES AGROPECUARIAS—"DIA")

Canuto Cardona A., PH.D., Director
Jacinto López H., ING. AGR., Acting Director
Emigdio Pinzón M., VETERINARIAN, Subdirector
Milciades Martínez G., VETERINARIAN, Head, Publications Office
Enrique Trujillo M., Administrator

EXPERIMENT STATIONS

Pedro María Contreras C., VETERINARIAN, Director, Armero Station
Alvaro Gartner N., M.S., Director, Tibaitatá Station
Jorge E. Ramón J., ING. AGR., Subdirector, Tibaitatá Station (until August, 1960)
Jorge L. Suescun G., ING. AGR., Subdirector—Farm Administration, Tibaitatá Station
Luis Alberto Rojas M., ING. AGR., Acting Director, Surbatá Station, Duitama (until August, 1960)
Alfredo Fernández M., ING. AGR., Director, Surbatá Station, Duitama
Orlando Sánchez E., ING. AGR., Director, Nataima Station, El Espinal
Luis Carlos Wiedemann T., VETERINARIAN, Director, El Nus Station
Ernesto Arango U., ING. AGR., Director, Tulio Ospina Station, Medellín
Bernardo Salazar R., VETERINARIAN, Director, Montería Station and Turipaná Station, Cereté
Jaime Medina P., ING. AGR., Director, Obonuco Station, Pasto

Enrique Llano G., ING. AGR., Director, Palmira Station (until August, 1960)
Carlostadio Sánchez P., M.S., Director, Palmira Station
José Joaquín Cortés C., VETERINARIAN, Director, San Jorge Station, Soacha
Reynaldo Rubio R., VETERINARIAN, Director, Toluviejo Station
Alfredo Usme R., VETERINARIAN, Director, La Libertad Station, Villavicencio

OFFICE OF SPECIAL RESEARCH
(OFICINA DE INVESTIGACIONES ESPECIALES—"OIE")

U. J. Grant, PH.D., Director OIE, The Rockefeller Foundation

CORN IMPROVEMENT

David H. Timothy, PH.D., Technical Director, Associate Geneticist, The Rockefeller Foundation
Ricardo Ramírez E., M.S., Codirector, Tulio Ospina, Medellín
Manuel Torregroza C., M.S., Geneticist, Head, Tibaitatá
Bertulfo Peña V., ING. AGR., Geneticist, Head, Tulio Ospina, Medellín
Efraín Diaz B., ING. AGR., Geneticist, Head, Palmira
Clímaco Cassalett D., M.S., Geneticist, Head, Turipaná, Montería
Daniel Varela A., ING. AGR., Geneticist, Tibaitatá
Daniel Sarría V., ING. AGR., Geneticist, Palmira
Fernando Arboleda R., ING. AGR., Geneticist, Palmira
Javier Gómez J., ING. AGR., Geneticist, Tulio Ospina, Medellín

WHEAT IMPROVEMENT

John W. Gibler, PH.D., Technical Director, Plant Pathologist, The Rockefeller Foundation
Charles F. Krull, PH.D., Assistant Technical Director, Assistant Geneticist, The Rockefeller Foundation
Mario Zapata B., M.S., Subdirector, Tibaitatá (on leave)
Rafael López O., ING. AGR., Geneticist, Head, Tibaitatá
Luis A. Rojas M., ING. AGR., Auxiliary Geneticist, Tibaitatá
Antonio Miranda H., ING. AGR., Auxiliary Geneticist, Tibaitatá
Hernando Reaga S., ING. AGR., Farinologist, Milling and Baking Laboratory, Tibaitatá
Marco Cano L., ING. AGR., Auxiliary Geneticist, Tibaitatá
Diego Robledo R., ING. AGR., Agronomist, Caja Agraria

BARLEY AND OAT IMPROVEMENT

John W. Gibler, PH.D., Technical Director, Plant Pathologist, The Rockefeller Foundation
Charles F. Krull, PH.D., Assistant Technical Director, Assistant Geneticist, The Rockefeller Foundation

Reinaldo Reyes N., ING. AGR., Geneticist, Head, Oat Improvement (commissioned by Quaker Oats Co.)
Luis A. García G., ING. AGR., Geneticist, Head, Obonuco, Pasto
Santiago Fonseca M., B.S., Auxiliary Geneticist, Tibaitatá
José A. Estévez C., ING. AGR., Auxiliary Geneticist, Tibaitatá
Rafael Contreras, ING. AGR., Agronomist, Procebada

ECUADORIAN WHEAT PROGRAM

John W. Gibler, PH.D., Technical Director, Plant Pathologist, The Rockefeller Foundation
Hernán Orellana J., ING. AGR., Technical Director, National Wheat Commission
José Galarraga G., AGRÓNOMO, Head, Izobamba and Santa Catalina Experiment Stations
Juan Sánchez P., AGRÓNOMO, Head, Wheat Improvement
Pablo Larrea H., ING. AGR., Geneticist
Galo Romero, ING. AGR., Auxiliary Geneticist

RICE IMPROVEMENT

Peter R. Jennings, PH.D., Technical Director, Associate Geneticist, The Rockefeller Foundation
Joaquín González F., ING. AGR., Auxiliary Geneticist, Palmira
Idinael López M., ING. AGR., Auxiliary Geneticist, Palmira
Manuel Rosero M., ING. AGR., Geneticist, Nataima, El Espinal (on leave)
Oscar Sohm K., ING. AGR., Auxiliary Geneticist, Nataima, El Espinal (on leave)

POTATO IMPROVEMENT

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Lauro Luján C., ING. AGR., Auxiliary Geneticist, Tibaitatá (on leave)
Edmundo Pérez M., ING. AGR., Auxiliary Geneticist, Tibaitatá
Luis A. Varón, ING. AGR., Auxiliary Geneticist, Tibaitatá (assigned to Popayán)
Carlos E. Rangel, ING. AGR., Auxiliary Geneticist, Obonuco, Pasto
Ladislao Tüdös V., ING. AGR., Auxiliary Geneticist, Tibaitatá

FORAGE AND PASTURE CROPS

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Silvio Echeverri E., ING. AGR., Auxiliary Agronomist, Tibaitatá (on leave)
Luis Alberto Varón C., ING. AGR., Auxiliary Agronomist, Popayán
Jaime Lotero C., M.S., Auxiliary Agronomist, Tulio Ospina, Medellín

Alfonso Bastidas R., ING. AGR., Auxiliary Agronomist, Palmira (on leave)
Rodrigo Ramírez O., ING. AGR., Auxiliary Agronomist, Tulio Ospina, Medellín (on leave)
Hernán Chaverra G., ING. AGR., Auxiliary Agronomist, Tibaitatá
José Vicente Silva P., ING. AGR., Auxiliary Agronomist, Palmira
Guillermo Riveros R., ING. AGR., Auxiliary Agronomist, Tibaitatá
Libardo Escobar R., ING. AGR., Auxiliary Agronomist, Turipaná, Cereté
Gustavo Herrera P., ING. AGR., Tulio Ospina, Medellín
Angelo Michelin P., PERITO AGR., Palmira

SOIL SCIENCE

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Genaro Díaz R., M.S., Soil Scientist, Tibaitatá
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Jaime Daza B., ING. AGR., Auxiliary Soil Scientist, Tibaitatá
Miguel Castellanos T., CHEMIST, Soil Laboratory, Palmira
Alix Luengas V., CHEMIST, Soil Laboratory, Tibaitatá
Manuel Rodríguez J., ING. AGR., Soil Scientist, Head, Tulio Ospina, Medellín
Jairo Gómez L., M.S., Auxiliary Soil Scientist, Palmira (on leave)
Rodrigo Lora S., CHEMIST, Soil Laboratory, Tibaitatá
Ramiro Guerrero M., ING. AGR., Auxiliary Soil Scientist, Palmira
Luis Alfredo León A., CHEMIST, Soil Laboratory, Palmira
Alejandro Hugo Manzano, ING. AGR., Auxiliary Soil Scientist, Palmira
Agathon Wieczorek P., ING. AGR., Auxiliary Soil Scientist, in charge, Nataima, El Espinal

PLANT PATHOLOGY

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Julia Guzmán N., PH.D., Plant Pathologist, Tibaitatá
Rodolfo Barriga O., ING. AGR., Auxiliary Plant Pathologist, Tibaitatá
Carmen Llanos M., M.S., Auxiliary Plant Pathologist, Tibaitatá
José J. Castaño, M.S., Auxiliary Plant Pathologist, Acting Head, Tulio Ospina, Medellín
Guillermo E. Gálvez, ING. AGR., Auxiliary Plant Pathologist, Palmira (on leave)
Enrique Torres T., ING. AGR., Auxiliary Plant Pathologist, Palmira

ENTOMOLOGY

Robert F. Ruppel, PH.D., Technical Director, Entomologist, The Rockefeller Foundation
Miguel A. Revelo P., M.S., Entomologist, Acting Subdirector, Tibaitatá

Lázaro Posada O., M.S., Entomologist, Tibaitatá
Gilberto Bravo V., ING. AGR., Entomologist, in charge, Obonuco, Pasto
Carlos Carmona B., ING. AGR., Entomologist, Head, Tulio Ospina, Medellín
Eduardo Idrobo M., ING. AGR., Auxiliary Entomologist, Palmira
Luis Restrepo T., ING. AGR., Auxiliary Entomologist, Tulio Ospina, Medellín
Alfredo Saldarriaga V., M.S., Entomologist, Head, Palmira
Isabel S. de Arévalo, M.S., Auxiliary Entomologist, Tibaitatá

BEEF CATTLE

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Camilo Duque G., B.S., Animal Husbandman, Tibaitatá
José Manuel de Bernardo Alvarez R., VETERINARIAN, Animal Physiologist, Tibaitatá (on leave)
Gustavo Riveros R., VETERINARIAN, Animal Physiologist, Tibaitatá
Omar Patiño H., VETERINARIAN, Animal Husbandman, Palmira
Oscar Cardona A., VETERINARIAN, Animal Husbandman, Turipaná, Montería
José J. Gutiérrez, B.S., Animal Husbandman, Turipaná, Montería
Gustavo Hernández B., VETERINARIAN, Animal Husbandman, Turipaná, Montería
Foción González H., VETERINARIAN, Animal Husbandman, La Libertad, Villavicencio
Jairo Mora G., VETERINARIAN, Animal Husbandman, Armero

DAIRY SCIENCE

Robert K. Waugh, PH.D., Technical Director, Animal Scientist, The Rockefeller Foundation
Bernardino Rodríguez U., VETERINARIAN, Dairy Husbandman, Tibaitatá
Samuel Ramírez V., VETERINARIAN, Auxiliary Dairy Husbandman, Tibaitatá
Oswaldo Acosta J., VETERINARIAN, Dairy Husbandman, Palmira
Guillermo Cedeño S., D.M.V., Dairy Husbandman, Obonuco, Pasto
Alfredo Serrano Q., VETERINARIAN, Dairy Husbandman, Palmira
Juan José Salazar C., VETERINARIAN, Auxiliary Dairy Husbandman, Turipaná, Montería
Jaime Rubio U., VETERINARIAN, Auxiliary Dairy Husbandman, Turipaná, Montería

POULTRY

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Gonzalo Madiedo M., VETERINARIAN, Poultry Husbandman, Tibaitatá
Gilberto Cardona A., VETERINARIAN, Poultry Husbandman, Palmira
Hector Alvarez G., VETERINARIAN, Poultry Husbandman, Tulio Ospina, Medellín

SHEEP

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Jerome H. Maner, PH.D., Technical Director, Assistant Animal Scientist, The Rockefeller Foundation
Nestor Morales A., VETERINARIAN, Sheep Husbandman, San Jorge, Soacha

SWINE

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Jerome H. Maner, PH.D., Technical Director, Assistant Animal Scientist, The Rockefeller Foundation
Jorge Gallo C., VETERINARIAN, Swine Husbandman, Tibaitatá

VETERINARY SCIENCE

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Eduardo Aycardi B., VETERINARIAN, Station Veterinarian, Tibaitatá
Guillermo Mateus V., VETERINARIAN, Station Veterinarian, La Libertad, Villavicencio
Otto Sánchez R., VETERINARIAN, Station Veterinarian, San Jorge, Soacha
Hernán López R., D.M.V., Station Veterinarian, Toluviejo (on leave)
Guillermo Cedeño S., D.M.V., Station Veterinarian, Obonuco, Pasto
Casimiro Molina S., VETERINARIAN, Station Veterinarian, Armero
Hernán Zaraza O., VETERINARIAN, Station Veterinarian, Turipaná, Montería
Hector Alvarez G., VETERINARIAN, Station Veterinarian, Tulio Ospina, Medellín
Gustavo Rave V., VETERINARIAN, Station Veterinarian, Palmira
Omar Hincapié N., VETERINARIAN, Acting Head of Laboratories, Tibaitatá

BIOMETRY

William H. Hatheway, PH.D., Technical Director, Associate Statistician, The Rockefeller Foundation
Pedro R. Oñoro C., ING. AGR., Biometrician, Tibaitatá (on leave)
Luis E. Castiblanco G., ING. AGR., Auxiliary Biometrician, Tibaitatá

FARM ADMINISTRATION

Roland E. Harwood, B.S., Technical Director, Associate, Experiment Station Operations, The Rockefeller Foundation
Jorge Quintero P., ING. CIVIL, Head of Engineering, DIA (on leave)
Horacio Ochoa R., ING. AGR., Farm Administrator, Palmira
Marco T. Arellano O., ING. CIVIL, Auxiliary Engineer, DIA
Ramiro Cardona G., ARCHITECT, Auxiliary Architect, DIA
Alberto Angel V., ING. CIVIL, Auxiliary Engineer, DIA

The barley plot in the foreground received no phosphorus; the one immediately behind received 80 kg./ha. of P_2O_5.

Director's Introduction

The population of Colombia has continued to increase at an extremely high rate while food production, in spite of recent advances in technology, has remained inadequate. The lag in the food supply is evidenced by the fact that rice and corn were added to the importation list during 1960-1961. This suggests that every means available, including research and extension programs, should be made more effective to help alleviate the deficit in food supplies.

The realization by the government and people of Colombia of the acuteness of the problem of agricultural production has highlighted the value of research and experimentation as the base from which advances in production must start. Typical is the increased interest in applying research methods in the utilization and industrialization of tropical fruits. The meat packing industry is similarly inaugurating intensive studies to explore the possibilities of exporting meat and meat products. Potentially the beef cattle industry in Colombia could equal the dollar value of coffee if it were properly developed and utilized.

The intensification of research on the beef cattle and other animals, especially poultry and sheep, is taxing the facilities of DIA (División de Investigaciones Agropecuarias), the agricultural research organization of the Ministry of Agriculture.

Traditionally, wheat, barley, oats, potatoes, and several of the forage species are grown at elevations above 7,000 feet in Colombia. The challenge is now even greater than before to develop varieties of these crops suitable to the lowlands. The action being taken to meet this challenge is discussed later.

The past year has seen progress toward closer coordination among agricultural education, extension, and research. A report submitted by a Study Commission convened by the Rector of the National University was released in April, 1961. The commission strongly recommends that:

Long-time planning on organization and administration should aim at better coordination of the national entities in education, research, and extension. An

Agricultural Research and Education Branch should be established in the Ministry of Agriculture comprising DIA, the Extension Service, and the Colleges of Agriculture and of Veterinary Medicine of the National University (this would require the transfer of these colleges to the Ministry from the National University) and the Vocational Agricultural system including the Agricultural Normal Schools of the Ministry of Education.*

The commission elaborated a detailed plan to bring about the necessary coordination of the three basic disciplines and suggested various ways of changing present administrative channels of these services.

With the support of the Ministers of Education and Agriculture, the commission presented its report to the President of the Republic. Realizing that the commission's recommendations are basic to the future progress of technical agriculture in all of its aspects, the President forthwith appointed an all-Colombian follow-up committee to expedite the implementation of the recommendations. This committee is made up of the Ministers of Education and Agriculture and a number of well-informed citizens who are vitally interested in the rapid progress of Colombian agriculture.

The Foundation's agricultural program in Colombia continues to take on more of an international aspect as breeding materials developed by DIA show their usefulness over a much wider area. During the year members of the Colombian Agricultural Program staff visited Mexico, Chile, Ecuador, Peru, Brazil, Venezuela, Costa Rica, Japan, Taiwan, the Philippines, Thailand, India, and Ceylon. In some instances, information was being sought while in others the staff members were consulting on a specific problem such as wheat breeding in Peru and Ecuador, potato breeding in Ecuador and Venezuela, animal research plans, equipment, and buildings in Chile, and rice research in Asia.

Seed production by the Agricultural Credit Bank (Caja Agraria) continues to be one of the most valuable cooperative phases of the program. The Bank has begun to study ways and means of turning the bulk of the seed production business over to private industry. A meeting was held recently with government and private industry to explore various possibilities to accomplish this objective. Intense interest was shown on the part of a number of private industries in assuming responsibility for commercial production and distribution of seed. If this plan proves feasible, the Agricultural Credit Bank proposes to turn over seed production to private industry and to concentrate on the originally planned third phase of its operation, which is to furnish the services of inspection and certification of seed. Such a development should bring about larger volumes and wider distribution of good seed to Colombian farmers.

The corn contest held annually by the Agricultural Credit Bank in the Cauca Valley had more entries this year, but a slightly lower yield earned first prize as compared with last year. However, the winner of U.S. $570.00 and a silver cup grew 100 bushels of corn per acre on a 25-acre field.

When suitable hybrid corns were first released in Colombia, it was expected that the better informed farmers with larger acreages would benefit most. This has proved to be true, but various inspection trips this year in the Cauca Valley revealed that many farmers with only a few acres are buying and planting the latest hybrids.

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*Higher Agricultural Education in Colombia—A Framework for Teaching, Extension, and Research. The Commission on Higher Agricultural Education, Bogotá, April, 1961, pp. 6-7. (Mimeographed.)

It is estimated that 85% of the corn now being grown in the Cauca Valley is planted with hybrid seed.

Close cooperation has been maintained between officials of DIA and the Colombian Rice Federation during the year. Preliminary plans have been made in DIA to help train Federation personnel in breeding, production, and agronomic techniques of rice growing. Visits of mutual benefit have been made by officials of the Rice Federation and DIA to the major rice-growing sections of the country to survey the main problems of the industry and to determine what steps may be taken to cut down costs of production and raise the margin of profit of the rice growers. Adequate production will not be attained until suitable solutions to these problems can be found because it is considered that under present conditions of production rice is a marginal crop.

During the year a meeting of all the DIA experiment station directors was held in Bogotá. This conference did much to solve several vexing problems. In general, the simultaneous development of several experimental stations has placed a strain upon the budget and facilities of the organization. The conference of the station directors involved has done much to solve the attendant problems. This meeting will continue to be held at different experimental stations on appropriate occasions.

The primary objective of the Colombian Agricultural Program continues to be to train Colombian scientists in research principles and practices. Progress toward this goal must be viewed against the background of the great demand for experienced scientists and technicians created as the Colombian economy, and especially its agricultural sector, moves forward at an increasing pace. As in many other countries, salaries outside the academic and governmental communities are often attractively higher than those within them, and research and educational institutions are at a disadvantage in retaining even a nucleus staff. The ultimate solution will be the training of enough scientists and technicians to fill all needs; in the immediate future, however, the problem remains extremely acute.

The fellowship training program is continuing at about the same rate as last year, with 13 Master of Science and 2 Ph.D. degree candidates studying in the United States. Of this number, eight Master of Science and one Ph.D. candidate began studies during the report period. During the year four candidates returned to Colombia with their Master of Science degrees.

The stipulation presently in effect requiring candidates to pass an English examination given by the Colombian-American Center before beginning their studies in the United States is proving to be worth while. It is most gratifying to see the performance of the returned trainees. Their services are most useful and necessary to the development and progress of the country. A list of candidates who have returned to Colombia and those now studying in the United States is shown in the Fellowship and Scholarship section of this report.

Several Temporary Scientific Aides visited the program during the year. Their visits were, it is felt, mutually beneficial. Dr. Milton Sunde returned to his position of Professor of Poultry at the University of Wisconsin after successfully helping organize the poultry research program. Without the competent services of Mr. William Bailey the installation of the growth chambers would have taken a much longer time because several difficulties were encountered in wiring and power supply that were not anticipated. Dr. H. A. Borthwick also was extremely helpful in getting the growth chambers into rapid operation; his technique of utilizing light to speed up the flowering of plants has been quite useful. Dr. E. C. Young's survey of various problems in the field of agricultural economics in Colombia was helpful. It is urgent that we move ahead with several studies in this field. Additionally, a number of outstanding scientists visit the program every year. Their contributions to the program are always greatly appreciated.

Several staff changes occurred during the year. Dr. Robert Waugh was designated Assistant Director of the Colombian Agricultural Program. Dr. David H. Timothy resigned to join the staff of the Agronomy Department at North Carolina State College. Dr. Charles Krull joined the staff as assistant small grains breeder. Dr. Lyndon Carew arrived in Colombia to take charge of the poultry research program, and Dr. Jerome Maner began his duties as head of the sheep and swine programs.

PROGRESS

The new Foundation staff additions, especially in the animal sciences, helped to round out these programs but the full complement of local staff must be designated as rapidly as budget permits. Since the animal industries are extremely important to the agricultural economy of the country, research in these fields should be greatly accelerated. Research programs are now under way on beef cattle, dairy, sheep, hogs, poultry, and veterinary medicine. The primary emphasis is especially on management and nutrition since more rapid progress can be made in these fields. However, physiology, disease control, breeding, and selection also constitute an important part of the research.

A start was made this year on the introduction of the necessary breeding animals. Thirty head of Holstein heifers of good pedigree were imported from the United States along with 240 head of sheep—approximately 50 ewes and 10 rams of each of the Romney Marsh, Corriedale, Rambouillet, and Hampshire breeds. In addition, 165 head of sheep, imported directly by the Ministry of Agriculture, were turned over to DIA to increase the breeding flocks. It has been agreed that twice this number selected by DIA, and not needed for the breeding flocks, will be returned to the Ministry for sale to private breeders. Frozen semen from proven sires is starting to be used and should contribute to improvement of the Holstein dairy herd.

Since coffee is an important crop in Colombia, feeding trials were carried out with oil-extracted coffee meal fed to dairy heifers. The results indicate that the meal is not as good as straight grain concentrate but when concentrate is scarce, it could be used effectively in mixtures of up to 25% coffee.

When baby pigs were placed on growing-fattening diets during the first eight weeks after farrowing, some of them reached a market weight of 100 kg. at five months of age. Losses of baby pigs remain higher than normal, primarily because of a lack of farrowing and other facilities.

With the completion of the water purification plant for the animal barns and the near completion of the dairy, beef, animal pathology, and poultry buildings at Tibaitatá, much advance has been made. All 11 experiment stations with livestock now have clinic buildings and personnel to supervise maintenance of animal health. The first buildings have been started at Cereté on the northern coastal plain. This will be the main tropical station once it is completed. The building of physical plants, including water and electrical installations, remains the most important and most costly problem facing DIA and will be so for three to five years in the future, until the major constructions have been completed.

Promising results, although preliminary, have been obtained in the poultry program. Several promising diets have been devised utilizing materials locally available. The conversion rate of feed to meat appears to be competitive with the best results found elsewhere. Hatchability of eggs, normally low at higher elevations, was improved in incubation studies using arsenilic acid.

Improved grass varieties resistant to bacterial gummosis are being propagated. Renovation of old pastures by sod scarification has shown promising results in establishing new grass and legume species.

Results are starting to show up in the long-term studies of soil management practices at Tibaitatá and Palmira. Yields of wheat, barley, and potatoes have doubled or tripled with the addition of phosphorus on the continuous cropping tests at Tibaitatá. For the first time in 10 consecutive corn plantings at Palmira, yields have been significantly lower when nitrogen was omitted. Corn in rotation with alfalfa and soybeans yielded 25 bushels per acre more than continuous corn.

Encouraging results in the control of barnyard grass (*Echinochloa colonum*) with a new herbicide have been obtained. This is extremely important since this pest is one of the limiting factors of successful rice production in Colombia. New products for control of weeds in corn were also found.

The study now in progress for more than 10 years on maize of the Andean region is drawing nearer to conclusion with the completion of the studies of the races of Ecuador and Venezuela. These works will soon be in press. The value of these studies is re-emphasized with the release of hybrids on the other side of the globe in India which utilize breeding materials from the Andean Region.

Three growth chambers referred to earlier in this report were placed in operation during the year. Data from wheat and oat rust tests and other data obtained from these chambers indicate strongly that the results previously obtained in greenhouses fitted with "Floral Breeze" equipment are reliable and can be utilized. If this proves to be true, then the cost of the growth chambers has already been justified.

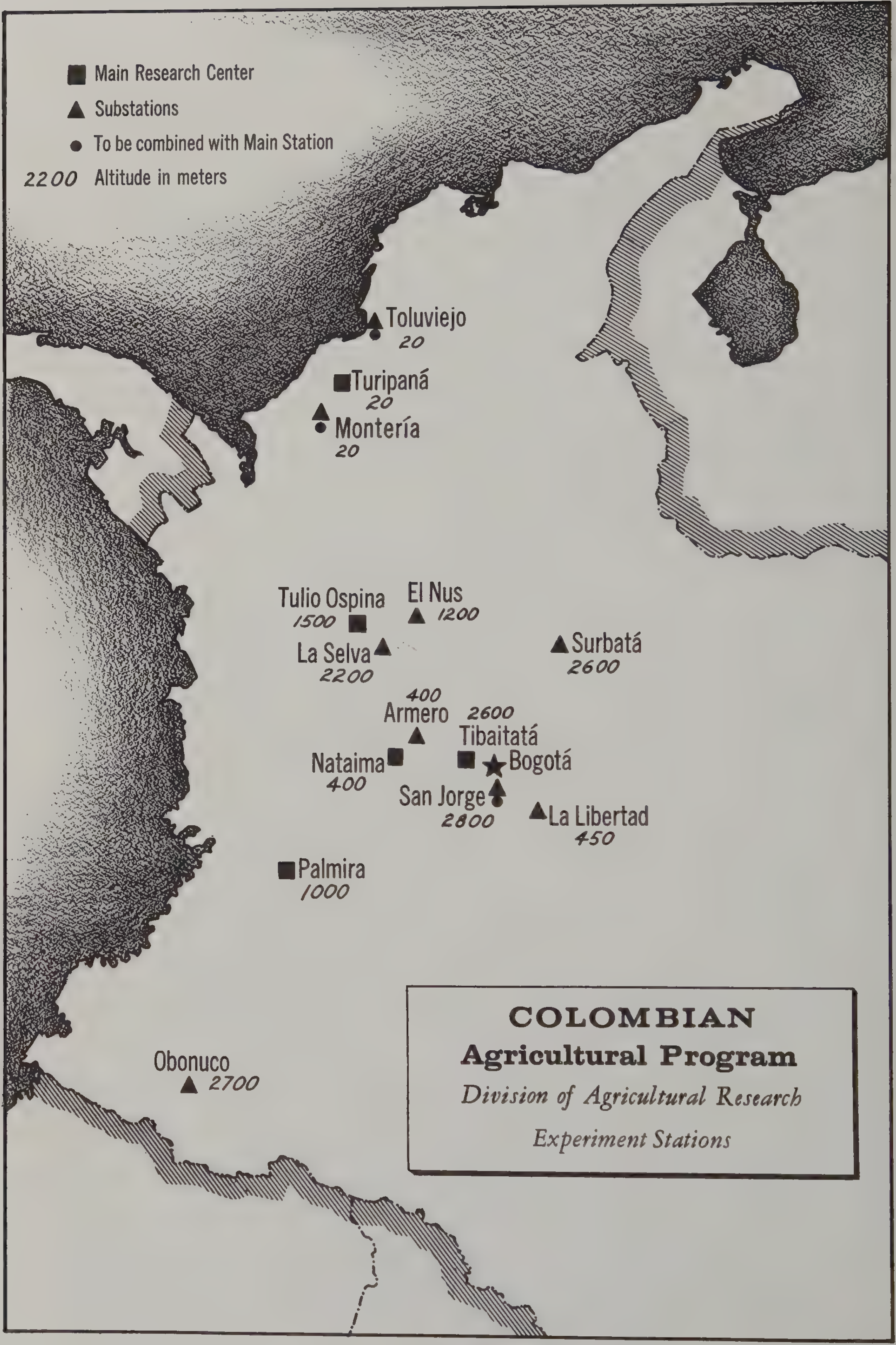
Work on the potato storage plant has progressed to the point that most of the divisions and bins have been constructed. The insulation and refrigeration remain to be completed before this plant can be placed in full-scale operation.

The first multilineal wheat variety developed out of Frocor and related material is being increased for release to the Caja Agraria later this year. The indications are that this new type wheat variety will withstand rust and other disease attacks for a much longer period of time than single line varieties. Therefore the average duration of a multilineal wheat variety should be much greater than that of standard varieties.

The oat program received a serious setback with the appearance of virulent races of oat stem rust capable of attacking all known varieties thought to be stem rust resistant. In order to isolate sources of resistance, the entire U. S. Department of Agriculture world oat collection will be screened on a race by race basis.

Biological control using the bacterial pathogen *Bacillus thuringiensis* was effective against the corn budworm, corn stalk borers, and some stored grain pests. Other unidentified pathogens were also found to be effective against other pests; a fungus was found that parasitizes the human bot fly or "nuche."

Experiments with large numbers of entries are now being statistically analyzed by electronic computer. The assistance of the Bavaria Brewing and Malting Company in furnishing free time on their computer has been most valuable.



COLOMBIAN
Agricultural Program
Division of Agricultural Research
Experiment Stations

Experiment Stations of the Division of Agricultural Research, Ministry of Agriculture, Colombia.

Location	Name	Size (acres)	Altitude (meters)	Av. temp. (°F.)	Av. rainfall (inches)	Soil types	Principal fields of investigation	Type of agriculture in region served
MAIN STATIONS								
Bogotá, Cundinamarca	Tibaitatá	1,404	2,600	57	29.55	Clay and silt loam	Corn, small grains, potatoes, beans; Horticulture; Forage crops; Soils; Entomology; Animal sciences; Plant and animal pathology	Diversified: all crops and animals
Medellín, Antioquia	Tulio Ospina	408	1,500	70	63.04	Loam	Corn, beans; Soils; Entomology; Plant pathology; Poultry	Corn, beans; Beef and dairy animals
Palmira, Valle del Cauca	Palmira	943	1,000	75	40.98	Clay loam	Corn, rice, beans, sugar cane, vegetables; Soils; Entomology; Plant pathology; Animal sciences	Corn, rice, beans, sugar cane; Soybeans; Pasture crops; Poultry; Cotton
Espinal, Tolima	Nataima	553	400	83	68.56	Sandy loam	Rice, vegetables; Forage crops; Soils; Entomology	Corn, rice; Sesame; Cotton; Beef animals
Cereté, Córdoba	Turipaná	4,495	20	82	41.76	Clay loam	Corn; Forage crops; Entomology, Animal sciences; Plant and animal pathology	Corn; Cotton; Beef animals
SUBSTATIONS								
Pasto, Nariño	Obonuco	1,421	2,700	55	35.46	Silt loam	Small grains, potatoes; Entomology; Dairy animals; Plant and animal pathology	Small grains, potatoes; Beef and dairy animals
Duitama, Boyacá	Surbatá	184	2,600	59	31.13	Clay	Small grains, potatoes	Small grains, potatoes; Beef animals
Soacha, Cundinamarca	San Jorge	1,929	2,800	56	27.58	Clay	Sheep; Animal pathology	Sheep; Potatoes
Rionegro, Antioquia	La Selva	168	2,200	63	55.16	Silt loam	Corn, potatoes, beans, vegetables; Forage crops; Entomology; Plant pathology	Corn, potatoes, beans; Dairy animals
Villavicencio, Meta	La Libertad	3,336	450	79	167.84	Loam	Beef animals; Animal pathology	Rice; Beef animals
San José, Antioquia	El Nus	2,716	1,200	75	88.73	Loam	Beef and dairy animals; Animal pathology	Beef animals
Armero, Tolima	Armero	1,656	400	84	72.89	Sandy loam	Beef animals; Animal pathology	Corn, rice; Sesame; Cotton; Beef animals
Toluviejo, Bolívar	Toluviejo	2,660	20	82	22.66	Sand	Beef and dairy animals; Animal pathology	Cotton; Beef and dairy animals

The hybrid Diacol H-501 has been developed for the cold-climate zone.

Corn

The primary objective of the corn program is to increase corn production in Colombia. To achieve this goal, emphasis has been placed on training Colombian agronomists to carry out a sound breeding program and on coordinating their efforts. Related activities of the corn program include the maintenance of stocks in the Maize Germ Plasm Bank in Medellín, production of foundation seed stocks, and advice and technical assistance for the commercial seed production of hybrids and synthetics.

Since 1957, emphasis in training has been increasingly shifted from straight inbreeding and hybridization procedures to studies involving more consideration and analysis of the fundamental principles of genetics, and their application to corn improvement. Through modification of a few procedures in most of these studies, it has been possible to use the results in the breeding program, to obtain basic information, and to facilitate better training of the agronomists through use of the data and problems for thesis studies and publication.

Corn is the most widely grown cereal crop in Colombia. It is planted from sea level to about 10,000 feet elevation, under conditions which range from tropical rainforests or semideserts, through semitropical, to cool alpine-like climates. The special environmental niches among the mountains and valleys within the different ranges of altitude necessitate a number of breeding centers if improved corn is to be created for use throughout the country.

RACES AND COLLECTIONS

Through the past, Indian tribes, settlers and colonists, and farmers have maintained genetically diverse strains of maize. Life for these people depended upon corn, and their seed stocks were rigorously selected for desirable characters. With the advent of modern agriculture, improved corns, and rapid transportation, these highly specialized strains of corn have been gradually disappearing. To prevent the irreplaceable loss of the genes in these varieties, the Committee on Preservation of Indigenous Strains of Maize was formed by the National Academy of Sciences—National Research Council in the United States. In cooperation with The Rockefeller Foundation, the committee sponsored a project to collect, preserve, and study for future use as many strains of indigenous corn as possible. The collections from the Andean region of South America have been essentially completed and are stored in the Andean Germ Plasm Bank in Medellín, Colombia. Additional collections are received from time to time; the total number is 5,986. It should be noted, however, that more collecting should be done in certain areas, particularly in the lowlands east of the Andes along the Amazon and Orinoco river basins.

The descriptions of the types of corn in the Germ Plasm Bank are nearing completion. During the past year, *Races of Maize in Bolivia* was published. *Races of Maize in Chile* is now in press and *Races of Maize in Ecuador* is in final manuscript form. *Races of Maize in Venezuela* is partially written and all data for this bulletin have been collected. These bulletins are being published by the National Academy of Sciences—National Research Council.

BREEDING PROGRAM

Breeding investigations are conducted at five main stations: Montería (50 meters elevation), Palmira (1,000 meters), Tulio Ospina (1,500 meters), La Selva (2,200 meters), and Tibaitatá (2,600 meters). A given type of corn can be moved only within a narrow range of environmental differences, and these stations are necessary to represent the major areas in which corn is grown.

At the highland stations, Tibaitatá and La Selva, studies are carried out primarily to obtain modified hybrids, synthetic varieties, and intervarietal crosses. Farming systems, rural transportation, and topography in the higher altitudes, coupled with personnel shortages in the corn program, dictate these objectives. At the lowland stations, the main emphasis has been placed on double-cross hybrids, with secondary attention to synthetic varieties.

Two double-cross hybrids, one modified hybrid, and a synthetic variety were released for commercial production in early 1960. These improved corns are highly acceptable in the market. No new improved corns were released during the past 12 months, although a number of synthetics and hybrids appear promising. Some of the hybrids have yielded up to 10 tons/ha.

If these promising materials continue to perform well, a number of them will probably be released next year:

La Selva—a modified hybrid yielding 30% to 45% more than the regional variety. This

Planting basic seed to produce the hybrid Diacol H-501. The four-row planter is seeding the feminine parent, Cundinamarca 365, and the two-row planter the masculine parent, Ecuador 466.

will be the first improved maize released for the region, 2,000 to 2,400 meters above sea level;

Montería—a yellow double-cross hybrid yielding 20% to 25% more than Diacol H-102;

Montería—a white double-cross hybrid yielding 10% to 45% more than Diacol H-151.

SPECIAL STUDIES

Studies on the mode of gene action are being continued. Preliminary data from Palmira for some varieties are in line with results obtained in the United States and also help explain the breeding behavior of the varieties used. Modification and addition of techniques of a Design I biparental experiment were used in these studies to form a number of synthetics in Eto and Eto Blanco, two outstanding varieties. Three synthetics were made in each variety using selection pressures of 10%, 20%, and 30% against the original population. The three first-cycle, third-generation synthetics of Eto Blanco yielded 12%, 18%, and 22% over the original parent variety. Results with Eto were not so favorable, the synthetics yielding only 0, 7%, and 18% over the original Eto.

To replace Diacol V-101, a high-yielding variety poorly accepted in the market because of soft grain texture, a series of intervarietal crosses was made at Palmira. Outstanding among these crosses were Diacol V-1 × Eto Blanco and Diacol V-1 × Nariño 330 Blanco. Heterosis estimates were 36% and 22%, respectively, more than the highest yielding parent. Both the F_2 and F_3 generations of these crosses yielded about 15% more than the high parent (Diacol V-1). The F_2 and F_3 generations also yielded 6.9 tons/ha., exceeding the variety to be replaced by 10%. If the performance of this material continues favorable, mass selection for more desirable plant and ear type should result in a highly acceptable variety which could be released in the near future.

At Tibaitatá, synthetics of Blanco Rubí and Harinoso Mosquera formed by recurrent selection have been disappointing. First-cycle synthetics of Harinoso Mosquera and Rocamex V-7, however, yield 10% and 21% more, respectively, than the original varieties. These studies are being continued.

Intervarietal crosses constitute a very efficient and useful means of determining which varieties should be carried along in the breeding program. They also furnish heterosis estimates. In the past a large number of crosses of local × local varieties, and local × exotic varieties, have been made. At Tulio Ospina, the eight best double crosses contained germ plasm from an inbred line from the United States. The yields of these double crosses ranged from 8.7 to 9.4 tons/ha., 10% to 19% over the yellow hybrid released last year and as high as 78% over the regional native variety.

Cooperative work with the entomology and plant pathology sections is being continued. A number of inbred lines resistant or tolerant to leaf and stalk diseases and insect pests have been selected.

Wheat yield trials, Izobamba Experiment Station, Ecuador.

Wheat

The new wheat variety Nariño 59 is now in the hands of farmers and has given outstanding commercial yields. The average on one 230-acre farm was 82 bu./acre, and a yield of 135 bu./acre was reported on another 10-acre farm. The over-all average was about 30 bu./acre on 6,250 acres of increase fields of the Caja Agraria. The variety has also performed well in commercial seedings at high elevations in Ecuador and Peru and in experimental plantings in Guatemala and Costa Rica. It has one disadvantage in that it is moderately susceptible to stem rust (*Puccinia graminis* var. *tritici*) at elevations below 2,600 meters. However, the variety Bonza is still resistant to stem rust and can be grown below that level.

A breeding program to produce varieties for the hot climate areas of Colombia was reinitiated at Palmira. Table 1 lists the number of lines studied at Palmira as well as at other experiment stations. The hybrid Thatcher-Santa Catalina × Frocor is in preliminary multiplication at Palmira, but sufficient information is not yet available on quality and adaptation to justify commercial release. It has performed well at the Monte Sacro farm in Venezuela. Other high-yielding hybrids are under test.

Yields of several promising hybrids are given in Table 2. These varieties are being tested in regional trials. If yields and quality continue to be acceptable, one or more will be multiplied. Regional trials are carried out cooperatively with the Caja Agraria and Procebada. Both organizations have commissioned agronomists with vehicles to work with the small grains program in this phase.

Considerable emphasis is still being given to dwarf wheats in the breeding program. Selections are being carried out in crosses made with Colombian, Mexican, Peruvian, and Japanese dwarf varieties. Most genetic dwarfs carry undesirable genetic factors that cause shriveled grain under Colombian conditions. Crosses and backcrosses are being made to remedy this defect.

The multilineal breeding program has reached the stage where the first composite variety will be ready for release in 1961 or early 1962. Approximately 1,500 individual Frocor backcross lines were in preliminary

TABLE 1.

Number of wheat lines studied in Colombia and Ecuador during 1960.

	COLOMBIA							ECUADOR		
	Tibaitatá	Surbatá	Palmira	Obonuco	Gachancipá	Rosal del Monte	Regional trials	Izobamba	Regional trials	TOTAL
Yield trials	3,750	3,750	8,086[a]	6,100	3,800	1,550	25[b]	2,135	9[c]	29,205
Generation (F_1)	1,396	211	–	–				–		1,607
Generation (F_2–F_8)	16,340	44,414	5,408	–				14,990		81,152
Crossing block	294	294	294	–				–		882
Small plots	103	–	–	27				88		218
Multiplication	–	–	1	–				5		6
Purification lines	725	–	–	420				–		1,145
International wheat rust nursery	1,611	601	1,010	519				–		3,741
F_2 from Chile	1,823	–	–	–				–		1,823
Lines from Chile	400	–	–	–				–		400
Lines from Kenya	136	–	–	–				–		136
Lines from Mexico	3,350	–	–	–				–		3,350
International yield nursery	100	–	–	–				–		100
Miscellaneous	2,292	2,292	–	–				–		4,584
TOTAL	32,320	51,562	14,799	7,066	3,800	1,550	25	17,218	9	128,349

[a] Including 268 lines seeded in a regional trial near Palmira.

[b] Planted at 17 locations in the Departments of Cundinamarca, Boyacá, and Nariño.

[c] Planted at 9 locations.

TABLE 2.

Yields in percentage of Bonza[a] of 11 promising hybrid-derived wheat lines as compared with native and improved check varieties of wheat in 1960.

Name and number of cross or variety		Yield trials			Regional trials[b]	Small plots
		Tibaitatá	Surbatá	Obonuco		
Diacol Nariño		104	105	168	132	122
Frocor-Frontana/Yaqui × Nariño	9314-22t-1b-1t	116	108	151	114	142
Yaqui-Kentana × Africa-Mayo 48	12330-2t-1b-3t	134	116	–	–	182
Yaqui-Kentana × (Africa-Mayo 48)^2	12947-3b-3t	136	113	–	–	206
Marroqui-Renown^2 × Frocor	III-28-3t-6b-3t-2b-1t	110	–	134	–	–
Lerma-Yaqui/Kentana × Frontana/Emabarmu-Lerma 50	9135-3b-2t-1b-1t-1b	115	103	142	165	157
Lerma-Selkirk × 1879	9067-2b-1t-1b-1t-1b-2t	114	107	137	185	159
[Frocor × (Newthatch/Mentana^2-Kenya × Bagé)] × Gabo	11263-3t-1b-2t-1b-1t	118	109	121	–	148
(Frocor-Frontana/Yaqui × Frontana/Yaqui-Menkemen) × (1829-Mayo 54 × 1829-Frontana/Yaqui)	10173-5b-7t-1b-1t-1b	124	112	112	–	185
1879-Mayo 54 × Bonza^2	11715-6b-1t-1b-3t	122	102	–	–	185
Frontana/Yaqui-Mayo 54 × Menkemen	10668-4t-2b-1t	97	97	139	149	134
Bonza (Improved check variety)		100	100	100	100	100
Ciento Cincuenta (Native check variety)		65	76	87	80	69
Bola Picota (Native check variety)		76	67	60	65	64

[a] The average yields of Bonza were 4.6, 4.8, 4, 2, and 3.5 tons/ha. per acre, respectively, from Tibaitatá, Surbatá, and Obonuco, regional trials, and small plots.

[b] Average of 11 harvested regional trials.

Multiplication plots of the new wheat variety Nariño sib (left) and advanced yield trials (right).

and advanced yield trials. Data were taken on maturity, height, phenotype, and disease resistance. Some 500 disease-resistant strains phenotypically equal to the Frocor recurrent parent were selected for advanced yield trials. Additionally, 80 of the best yielding, nonsister lines of this group will be placed in regional yield and adaptation trials in the northern zone of the Savannah of Bogotá, and will be multiplied in small plots at the Tibaitatá station the first semester of 1961. These 80 lines will be reduced to about 10 on the basis of their responses in the regional and experiment station trials. Each will be multiplied to about 20 tons of seed, mixed, and the resulting 200 tons will be turned over to the Caja Agraria for release in the northern zone of the Savannah of Bogotá, probably under the name Frocor 62. Thus the composite variety will be made up of a mixture of 10 genotypically different lines, each comprising only 10% of the mixture. It is highly improbable that a new race of yellow rust could arise in nature capable of attacking all 10 different sources of resistance. The probabilities are that a new race would attack no more than a few of the lines, and that the farmers' losses would thus be minimized should there be a shift in rust races. It would be difficult for an epiphytotic to develop since no more than a portion of the field population would be susceptible, and the susceptible plants would be surrounded by resistant plants.

The Frocor composite variety is almost ideally suited to the zone for the following reasons: (a) It is equal in quality to the variety Menkemen which it will replace. Both are soft-textured varieties suited for pastry flours. (b) It is well adapted in the zone; it is early maturing, high yielding, and tolerant to "vaneamiento" or pollen sterility. This condition is induced by brusque changes in temperature brought about by cold air draining down from the "páramos" of the surrounding mountains. (c) The Frocor backcross lines that form the composite are resistant to yellow or glume rust (*Puccinia glumarum*), which is a severe problem in the area. (d) Race changes in yellow rust have occurred at a high frequency in the zone. By being able to replace at will the susceptible portions of the composite, one would never be more than a year, and probably less, behind such race shifts. (e) The area is small enough so that seed stocks can be multiplied at the experiment stations under direct control of DIA agronomists.

The importance of commercially proving the first composite variety cannot be overemphasized. If it works in this area, the multilineal principle can be applied to producing wheats for regions throughout the world where rust is a limiting factor.

The lines that are not used will be stored for the future. Additionally, each of the 500 or more individual lines will be placed in a special nursery for planting throughout the wheat zones in order to try to anticipate any yellow-rust race changes. If any of the 10 individual lines forming the composite variety Frocor 62 become susceptible, one or more of the phenotypically similar, resistant lines can be substituted and the composite remade.

The same 1,200 Frocor lines were also planted in Peru at the Huancayo experiment station. They are well adapted and maintain the Frocor phenotype. About 400 have been selected for advanced yield trials in 1961. A Frocor composite would also work very well for the Sierra of Peru where both yellow and stem rust are problems.

The lines behave similarly in Ecuador. However, a Frocor composite will probably not be released there since quality equal to that of Menkemen is not good enough. A harder, stronger gluten wheat is needed for bread since nationally produced wheat makes up a greater percentage of the market than in Peru.

The Ecuadorian program is multiplying Nariño 59 and sister selections for release as well as other varieties (Table 1) and is testing several others in regional trials. An experimental flour mill has been purchased and should be installed by next year; this will help greatly in selecting the best quality varieties. The results of fertilizer studies show that in all zones phosphorus and nitrogen fertilizers are needed to grow wheat while potassium fertilizers are not needed in most soils.

Colombian wheat varieties have wide adaptation: here, a multiplication field of the variety Bonza at Arequipa, Peru.

One of the agronomists in the wheat section is on study leave as candidate for a Ph.D. degree at North Dakota Agricultural College. It is hoped that two more men may be sent to the United States for advanced training within the next year.

The interchange of genetic material with Mexico, Chile, and Kenya was continued (Tables 1 and 3). Table 3 lists the number of lines sent to other countries. The cooperative International Stem Rust Nurseries were again tested, as well as the Rockefeller Foundation Inter-American Wheat Project yield nurseries.

TABLE 3.

Number of wheat lines sent to other countries in 1960.

Country	Number of lines
Chile	3,750
Costa Rica	5
Ecuador	3,750
Guatemala	2
Kenya	3,750
Mexico	3,750
Nepal	1
Peru	3,750
Venezuela	25
TOTAL	18,783

Cross-pollinating a barley flower.

Barley

During 1960, barley production in Colombia increased to 110,000 tons with a corresponding reduction in imports, according to figures furnished by Procebada. Only 8,935 tons of malt were imported; and the probabilities are that imports will be reduced to almost zero in 1961. Production would have been higher during 1960 except that it was a very dry year and frost occurred in the second semester.

Procebada (the Colombian organization promoting barley production) distributed over 4,000 tons of seed of the improved barley varieties Funza and Galeras, an amount sufficient to seed about 135,000 acres. This is approximately 95% of all barley acreage in Colombia.

The urgent need for trained agronomists for the barley breeding program is on the way to being solved. A contract between DIA and Procebada is in advanced stages of discussion. Under the contract, Procebada will hire the agronomists, furnish them with vehicles where necessary, and commission them to the program. It is projected that each of the stations in the principal barley-growing departments will have at least one agronomist. The Obonuco station and the main station at Tibaitatá will receive the most emphasis, with at least two agronomists at each. The crossing phase of the program will be concentrated at Tibaitatá, which will act as a distribution center. Obonuco is very important because it is in the zone where the virus or virus-like disease "enanismo," or dwarfing, occurs. Since the poor-quality native Colombian barleys carry almost the only known source of resistance, they must be crossed with good malting-quality varieties. In this way resistant, high-quality barleys can be produced for all of Colombia. Up to now the disease has occurred only in Nariño and Ecuador, but if it ever becomes distributed in other zones it will be disastrous, since the variety Funza, grown on over 90% of the acreage, is susceptible. The enanismo-resistant variety Galeras that is now grown in the

Department of Nariño could be substituted for Funza but is of low malting quality and test weight.

Adequate quality testing of barley hybrids is the most urgent problem in the breeding program. Many barleys of excellent agronomic types are available at all stations. More than 35,700 barley varieties and lines were grown and studied at the different experiment stations during 1960-1961.

Before the hybrids can be used as commercial varieties they must have acceptable malting quality. Agronomic characters serve only as a rough guide to quality; hence the need for testing in a quality laboratory. Both Bavaria and Malterías Unidas (the local malting and brewing companies) have laboratories but have little time to devote to experimental testing. They also require about 5 kg. of seed for each test, an amount difficult to obtain since at least three growing seasons after crossing are needed to produce it.

Backcross breeding programs are in progress to cross the high-yielding, stiff-strawed, adapted varieties with the good-quality, introduced varieties Toluca, Traill, and Kindred. Concurrently, these high-quality varieties are being crossed with the best enanismo-resistant lines from Obonuco. Resistance to loose smut is being incorporated from several local hybrids and also from the variety Toluca.

The International Barley Disease Nursery was seeded at various locations, and notes were taken on disease development and heading date. No good source of resistance to the barley leaf diseases was encountered, but despite a high incidence of these diseases they were not a limiting factor to barley production. Seed of more than 3,880 lines of genetic material from the Colombian breeding program was sent to five different states and countries in 1960-1961.

Stem rust of oats is a very serious problem in Colombia.

Oats

The oat breeding program received a severe setback during the first planting season of 1960 when all the 5,331 lines under study that had shown resistance to the oat-stem-rust pathogen in past seasons were found to be highly susceptible at Tibaitatá and Surbatá. This is especially serious since this material had been selected for stem-rust resistance from a wide germ plasm base including the world oat collection of the U. S. Department of Agriculture, the International Oat Rust Nurseries, lines from various experiment stations, and some 1,200 crosses that had been made in Colombia. The amount of infection was high on all lines, and even the highly resistant diploid, Saia, had a reading of 90% susceptible. The attack was so severe that most strains in both the yield trials and segregating lines did not set seed.

Preliminary greenhouse work in cooperation with the plant pathology section indicates that individual races appear to be present that can attack all of the standard and supplementary differential varieties, including Saia. The international implications of the inadvertent spread or reproduction in nature of such virulent races cannot be overemphasized, especially when it is remembered that none of the lines obtained from the United States or Canada has shown any field resistance to this race complex.

The crossing program has been temporarily suspended until resistant parents are obtained from screening the U.S.D.A. world oat and species collections on a race for race basis. The U.S.D.A. has supplied a new set of these nurseries to begin the screening program. Three growth cabinets with controlled temperature and light have been installed and, with a temperature-controlled greenhouse, should supply sufficient equipment for this work.

The Quaker Oats Company has continued to support the breeding program by employing a Colombian agronomist to work entirely with the oat breeding program and by providing him with a vehicle. To aid the stem-rust work they have also provided a 30 KVA power plant to produce electricity for the growth cabinets.

Rice plots at Palmira.

Rice

Rice, according to many agricultural production surveys, is the most important Colombian food crop as measured by value of grain production, investment in land, machinery and equipment, and the number of farmers and workers employed by the industry. Land area devoted to rice is in excess of 500,000 acres and production is about 400,000 long tons per year, an amount which approximately meets local demand for consumption. The grain is neither imported nor exported in large quantities.

About two-thirds of the crop is grown under upland conditions without irrigation. Yields from upland rice are very low because of weed infestations, primitive cultural practices, and lack of water. The lowland, or irrigated, rice produces higher yields, but these do not compare favorably with yields in many other countries.

Varieties used in the irrigated areas are principally long-grain rices such as Bluebonnet 50, Rexoro, Fortuna, and Century Patna 231. Production in general is rather highly mechanized. Upland rice varieties include those mentioned above as well as a large number of unimproved native types. Colombian consumers strongly prefer long-grain rice with its dry cooking characteristics over the short- or medium-grain types which are more moist and sticky when cooked.

Breeding Program

VARIETAL IMPROVEMENT

Varietal improvement of rice, begun in 1958, is dedicated to the development of long-grain varieties having resistance to the hoja blanca and straighthead diseases, combined with stiff straw, a high tillering capacity, and the ability to withstand periods of cool weather.

Hoja blanca, a virus disease transmitted by the leafhopper *Sogata orizicola* Muir, for the past three years has been the most serious disease of rice in Colombia and in several other Latin American countries. As a result of severe losses in Bluebonnet 50, farmers in the Cauca Valley have replaced this variety with disease-tolerant but poorly performing native varieties having a medium grain type.

Several thousand introductions from Asia, Europe, and the Americas have been field tested for resistance to hoja blanca. Many excellent sources of resistance—mostly *japonica* types from Taiwan, Japan, and Korea along with a few long-grain *indica* rices from South America—have been selected and used in the crossing program. The *japonica* rices have short grain, are non-sensitive to photoperiod, and yield more than the best varieties grown commercially in Colombia. The resistant *indica* lines are tall and leafy, tiller profusely, and yield well but have poor straw. Although no variety is immune to the hoja blanca disease, these selections have greatly reduced leaf and panicle symptoms as compared with standard susceptible lines.

It has been found that a backcross system is essential for recovery of the long-grain type and for the elimination of hybrid sterility from crosses involving the *japonica* group; in crosses of resistant *indica* lines, it is necessary in obtaining stiff straw, acceptable grain shape and size, and good milling quality. Bluebonnet 50 has been used as a standard recurrent parent along with a number of United States breeding lines. It appears that grain shape and size are fixed early in hybrid populations and must be strongly selected for in the F_2 and F_3 plant generations.

The program has been fortunate in that at the Palmira station extremely severe epiphytotics of hoja blanca are present every planting season which facilitate selection of the desired resistant types. A considerable number of highly promising lines, from the first crosses made in 1958, will be entered in yield trials in the coming year. Backcross material of the cross Bluebonnet 50 × Gulfrose, from Beaumont, Texas, promises an improved and resistant Bluebonnet type which should enter multiplication within the near future.

A detailed study of inheritance of resistance to hoja blanca, using a large number of resistant and susceptible varieties, has been completed. Data from the F_1, F_2, F_3, F_4, and backcross generations indicate that resistance is conditioned by one major dominant gene, possibly supplemented by minor gene action from some of the resistant sources.

To calculate losses caused by hoja blanca at different levels of disease incidence, plot yields of Bluebonnet 50, a susceptible check variety, from all the yield trials planted to date in Palmira were compared with the disease rating given according to the scale 0 (no symptoms) to 9 (most severe attack). As seen in Figure 1, there is a straight line relationship between severity of disease and yield reduction. The most heavily attacked plots suffer an 80% loss as compared with plots having only traces of disease. It is interesting to note that at least some production is obtained even in the most severely damaged plots since diseased plants often have at least one tiller that produces some grain.

Straighthead, a physiological disease associated with sandy soil and continuously irrigated fields, has been increasing in severity at the Palmira and Nataima experiment stations as well as in the commercial rice areas of the Tolima Valley. Although thorough draining of fields at about 50-60 days following planting will control the disease, varietal resistance promises a more practical means of

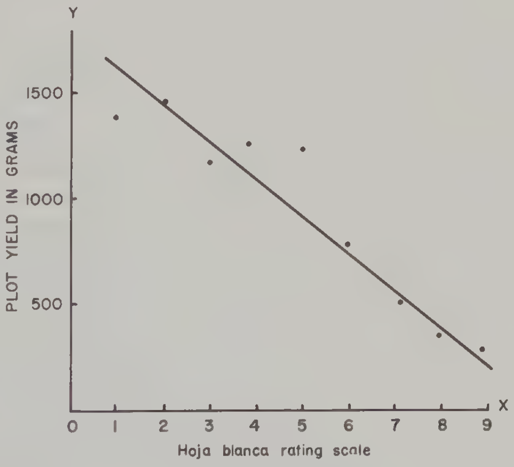


Figure 1. Regression of rice yield on hoja blanca infection, 52 plots. Y=1724.85—160.21 × ± 21.38 grams per unit of scale.

control, especially in areas where water is scarce. Several varieties used in the crossing program are resistant and increased attention is being paid to selection of resistant hybrid material.

Varieties and lines seeded during the year totaled 15,685 rows.

MULTIPLICATION OF GULFROSE

The severe losses occasioned by hoja blanca in several of the rice zones have created concern in the rice industry and a demand for a resistant variety. Gulfrose, C.I. 9416, a selection from the cross Bruinmissie Selection × Zenith, was chosen for multiplication because of its acceptable resistance and yield. It is a medium-grain variety characterized by resistance to certain races of blast, early maturity, rapid germination and excellent seedling vigor, moderate height, fair straw, and good total milling yield. Production in the multiplication field averaged 3 tons/ha. (58 bushels/acre) even though a low seeding rate was used so as to spread the original seed stock over as large a land area as possible. Approximately 20.5 tons of cleaned and classified seed were given to the Caja Agraria for distribution to farmers; high yields are being reported in the first commercial plantings.

Laboratory tests of milling yield and cooking quality were conducted by the National Institute of Foodstuffs (INA) before Gulfrose was released. The results were typical of medium-grain performance and the variety was rated as acceptable. The Nataima section distributed 65 unmarked packages to local consumers for evaluation of table appearance and quality. The majority of the replies indicated that the rice was highly acceptable, especially when cooked with less water and for longer periods at a lower heat than commonly used for long-grain varieties.

INTERNATIONAL COOPERATION

Six U. S. Department of Agriculture nurseries were planted in Palmira and evaluated for hoja blanca resistance. The nurseries of H. M. Beachell of Beaumont, Texas, have proven to be of special value since they comprise lines developed for the purpose of incorporating resistance into a Bluebonnet type. Selections made in Texas on the basis of hoja blanca notes from Colombia are tested for straighthead resistance and cooking quality and then sent to Colombia for continued testing for hoja blanca resistance.

Two distinct nurseries of the most promising resistant Colombian lines were sent from Colombia to Venezuela and Mexico for further evaluation. The Colombian rice program has been cooperating with the Mexican Agricultural Program to provide an early, stiff-strawed, high-quality rice for the Veracruz area. The discovery of hoja blanca in 1960 in the State of Veracruz underscores the value of this joint effort.

CULTURAL PRACTICE STUDIES

It has been considered from the initiation of the program that poor cultural practices are more responsible for low yields than diseases, pests, or inferior varietal performance. The inadequacies in crop management are basic and include methods and rates of seeding, fertilizer rates and timing, irrigation practices, and crop rotation. These factors contribute in various ways to severe weed infestations, an important and often the primary cause of low production.

The prevailing high production costs are the result of poor crop management—excessive seed, fertilizer, and labor are employed to combat weeds. Tall, leafy, late-maturing varieties, which compete with grass but often have low yield capacity, are preferred in some areas. Short-straw, narrow-leaf, early types with a high response to nitrogen and superior yield potential would give greater production and more efficient land utilization if combined with improved crop management.

DATE-OF-SEEDING STUDIES

This project, which has one more year before completion, has provided some interesting insights on seasonal variation in rice performance and hoja blanca incidence in the Cauca Valley. Ten varieties, including widely diverse types in grain and plant characters, disease reaction, maturity, and origin, have been seeded every month at Palmira since October, 1958.

Highest yields, earliest maturity, and tallest plants were obtained during the period February to April when rains were infrequent and warm, clear days prevailed. Correlations relating to the hoja blanca disease were calculated on the basis of the following hypothesis drawn from field observations: that rain during one month influences the *Sogata* populations in the following month and that the lag between insect feeding and full development of symptoms in the field is approximately 60 days. Thus, rain in one month foments insect build-up by the following month, which causes the hoja blanca that appears about two months later. These correlations are presented in Table 1. There appears to be a likelihood that rainfall plays a significant part in the epidemiology of hoja blanca, a disease noted in the past for its heavy attack in some seasons and minor incidence in others.

TABLE 1.

Correlations relating to hoja blanca from the date-of-seeding test.

Correlation between	Value	5% level	1% level
Rain and *Sogata*	+.651	.553	.684
Sogata and hoja blanca	+.637	.553	.684
Rain and hoja blanca	+.438	.553	.684

TRANSPLANTING

Transplanting is not practiced in the lowland rice zone of Colombia, although considerable portions of the rice lands of Ecuador and Peru are planted, with excellent results, by this method. Although its labor requirements are high, it was felt desirable to compare this method with the common broadcast seeding.

The results obtained show that transplanting was superior to broadcasting and that wider spacing and more plants per hill gave the greatest yields. An economic study of comparative costs and harvest value indicated that transplanting was a better practice than broadcasting. This method must be tested on a larger scale before definite conclusions on its value as a commercial practice can be drawn.

Of special interest is the high yield of the short-grain *japonica* variety, Shinchiku-iku, as compared with that of Bluebonnet 50, the standard variety in Colombia. This excellent production has been noted in previous tests and is not entirely explained by its resistance to hoja blanca. Since the short-grain type is unacceptable to the rice market, this and similar *japonica* types are used in the breeding program as sources of resistance and yield factors.

HERBICIDE TRIALS

Eptam 6-E (Ethyl di-n-propylthiolcarbamate), reported to be effective against barnyard grass, was tested in two locations with several dosages and methods of application. No control was evident.

In a test for control of broad-leaf weeds, 2,4,5-T ester applied at the rate of ¾ gallon per hectare at 50 days following seeding was more effective than the sodium salt of 2,4-D, 2,4-D, or Dow pre-emerge. The 2,4,5-T ester also gave complete residual control of nutgrass for several months following the harvest of the rice plots.

STAM F-34 (3,4-dichloropropionanilide) was tested as a post-emergence herbicide for control of barnyard grass. In this preliminary experiment grass was well controlled with applications made at the 2-4 leaf stage of grass at a rate of 6 kg./ha. Initial results were so promising that continued studies are in progress. Similar results have already been reported from Japan and the United States.

RICE CULTURE IN THE TOLIMA VALLEY

The Department of Tolima, the largest lowland rice-producing area in Colombia, has in recent years experienced steadily declining yields and increasing costs of production. The major reasons for this are:

(1) Excessive quantities of seed, averaging approximately 250 kgs. per hectare with a cost of 1.70 pesos per kg., are broadcast and lightly disked into the seed-bed, which all too often is poorly prepared. Considerable seed is lost from both deep and superficial placement and stands are irregular.

(2) The young crop is flushed to maintain soil moisture until 30 days after seeding, when the permanent flood is started. This delay stimulates luxuriant growth of grass and broad-leaf weeds. Furthermore, levees are poorly constructed so that the permanent flood is maintained at a minimum depth.

(3) Fertilizer applications are made at about 60 to 70 days following seeding once the weeds are partially dominated by irrigation water and hand cleanings. Nitrogen, phosphorus, and potash are applied by hand onto the drained soil in large quantities, the amounts varying from grower to grower. These applications, made during the second half of the life cycle of the rice plant, result in considerable loss of the phosphorus and potassium which are most available to the plant during the early stages of growth.

Several experiments have been completed on the following aspects of rice management.

Seeding Methods

Drill and broadcast seeding tests have shown that drill planting is superior. Lowered seeding rates can be used with this method, and fertilizers can be drilled into the row whenever desired. Germination is more rapid and uniform with drill seeding.

Seeding Rates

In repeated experiments, 150 kg./ha. of seed, drilled or broadcast, gave higher yields with less lodging than other rates ranging from 50 to 300 kg.

Phosphorus and Potassium

These elements applied at varying rates with or without nitrogen, or applied with the seed or topdressed at 45 days, gave no yield increase over the check plots in repeated tests. Soil analyses have shown these elements to be available in rather large amounts in the sandy loam soils of the region.

Nitrogen

Urea topdressed at 45 days has given startling yield increases. Application of all the nitrogen at 45 days has consistently been superior to application of half with the seed and half at 45 days.

The optimum nitrogen rate in three tests was about 150 kg./ha., an excessive level when compared with practices used in other countries which also favor *indica* type varieties. Efficiency of utilization is low in the sandy loam soils typical of the Tolima Valley and considerable nitrogen is lost. A study on split applications of nitrogen and another on sources of nitrogen as influenced by degree of soil moisture at the time of seeding and by time lapse prior to reflooding following application, are in progress to determine whether nitrogen loss can be reduced by management practices.

Irrigation

Farmers establish the permanent flood at about 30 days following seeding. Table 2 presents the results of a test designed to see if increased yield could be obtained through

TABLE 2.

Influence of time of flood on rice yield.

Treatment	Yield per plot (kg.)
Flood at 10 days	51.64
Flood at 10 days; drain at 15; flood at 20	52.03
Flood at 20 days	46.06
Flood at 20 days; drain at 25; flood at 30	46.27
Flood at 30 days (check plot)	40.60

L.S.D.—5% = 4.60; 1% = 7.61

earlier establishment of the permanent irrigation.

It would appear that irrigation begun at 10 days is superior to establishment of the flood at 20 or 30 days following seeding. The one drainage did not have an influence on yield. Weed control (estimated visually) did not seem to account for the large differences among treatments.

APPLICATION TO COMMERCIAL PLANTINGS

The two most recent large-scale plantings made at the Nataima station in the Tolima Valley yielded an average of nearly 3,200 kg./ha., about 60% over the regional average of approximately 2,000 kg. Farmers must harvest about 2,000 kg. to pay costs. Production expenses at Nataima were about 20% lower than those of the local farmers. The increased yields and lowered costs were a direct result of the application of results from investigation.

(1) The land received excellent preparation including leveling to eliminate high and low spots which are foci for weed growth. Repeated disking prior to seeding provided a partial basis for weed control. Broad, high levees were raised according to land slope to provide a maximum water depth.

(2) The grain was drill seeded with 45 kg. of P_2O_5. Uniform and rapid germination and excellent stands were obtained.

(3) The seeding rate of 140 kg. represented a saving of about 100 kg. or 170.00 pesos per hectare over the standard local practices.

(4) The permanent flood was established at 10 to 15 days following seeding and, in combination with good seed-bed preparation, gave nearly complete grass control. A minimum amount of labor was therefore required to hand weed the fields, and then only for elimination of broad-leaf weeds.

(5) Nitrogen was applied at the rate of 50 kg./ha. as a top-dressing at 45 days after planting and was more effective than applications made at 60 to 70 days by farmers when the rice.was well into the second half of its life cycle.

These practices, although demonstrably better than those of the region, can undoubtedly be further improved. Future plantings should yield even better with a possible greater reduction in costs, since P_2O_5 and K_2O will not be applied and nitrogen rates will be substantially increased. It would seem, however, that large gains in the future will depend mainly upon improved methods of increasing the availability of nitrogen to the plant.

The new potato variety Suma Paz.

Potatoes

The long-range development of the potato improvement program in Colombia has been based on the breeding work in progress during the past several years. The development and maintenance of a potato collection in Colombia has served as a basis for this breeding program, which is beginning to produce results in the form of higher-yielding, disease-resistant hybrids with improved agronomic characteristics.

Breeding

COLOMBIAN POTATO COLLECTION

Additional material is being obtained from various sources each year to supplement the potato collection. Several late-blight-resistant varieties were obtained from the U. S. Department of Agriculture and from Mexico. The diploid clones of *Solanum phureja* Juz. and Buk., collected in Colombia by Dr. K. S. Dodds, were also incorporated into the Colombian potato collection. Thirty haploid clones derived from varieties of *Solanum tuberosum* L., and various hybrids between wild diploid species and the cultivated diploids were obtained from the Potato Introduction Station at Sturgeon Bay, Wisconsin.

The breeding program is oriented toward the utilization of the various late-blight-resistant clones in the collection for the production of hybrids adapted to the various climatic conditions in Colombia. The selection of selfed progeny of the more promising clonal lines is being used to obtain greater homozygosity of material for use in breeding.

SCREENING OF HYBRID SEEDLINGS

During 1960, approximately 173,000 lines were produced from seedlings grown in the greenhouse and transplanted to the field. These lines were developed from approximately 750 individual crosses. The simple hybrid lines were obtained from the following basic crosses:

(1) *Solanum tuberosum* L., (2n=48) with one or two crosses to *S. andigenum* Juz. and Buk.

(2) *Solanum demissum* Lindl., (2n=72) with two or three backcrosses to *S. tuberosum* and *S. andigenum.*

(3) *Solanum curtilobum* Juz. and Buk., (2n=60) with one or two backcrosses to *S. andigenum.*

(4) *Solanum ajanhuiri* Juz. and Buk., (2n=24) with crosses to *S. phureja* and *S. andigenum.*

(5) *Solanum stoloniferum* Schlechtd., (2n=48) crossed with *S. phureja, S. andigenum,* and *S. tuberosum.*

These hybrid lines were exposed to natural infection of late blight under field conditions which eliminated approximately 90% of the lines planted. Plants showing virus symptoms or infected with *Alternaria* or *Rhizoctonia* were also eliminated. Only 4.5% of the total lines planted remained for harvest. Further selection at harvest time for agronomic characteristics eliminated all but 740 lines, or 0.7% of the total lines planted. These lines will be maintained in the hybrid collection for further observation, selection, and possible future multiplication.

It is hoped that in the future the methods developed for selecting late-blight-resistant lines in the laboratory and greenhouse can be used to eliminate the extensive labor required in the present system of field screening.

DIPLOID SPECIES

A potato breeding project at the diploid level (2n=24) was begun in 1959 in an attempt to combine characteristics of the various wild diploid species with some of the cultivated diploid species. The following diploid species were used in this breeding program: *Solanum simplicifolium* Bitt.; *S. neo-hawkesii* Ochoa; *S. macolae* Buk.; *S. toralapanum* Card. and Hawkes; *S. saltense* Hawkes; *S. commersonii* Dun.; *S. verrucosum* Schlechtd.; *S. maglia* Schlechtd.; *S. gibberulosum* Juz. and Buk.; *S. vernei* Bitt. and Wittm.; *S. polyadenium* Greenm.

These wild species were crossed with the following cultivated diploids: *S. phureja*; *S. yabari* Hawkes; *S. stenotomum* Juz. and Buk.

Selections from the first diploid crosses are being backcrossed to the cultivated diploid species to improve the agronomic characteristics. At the same time crosses between the various cultivated diploids are being made in an effort to combine their agronomic characteristics.

USE OF HAPLOID SPECIES

The development of haploid potato clones at Sturgeon Bay, Wisconsin, with *S. tuberosum* has stimulated great interest in the possible use of haploids in potato breeding. The development of haploids from *S. andigenum* was initiated in Colombia to obtain a wider base of haploid material for genetic studies. The haploid material provides a high degree of homozygosity which is otherwise difficult to obtain in potatoes. The presence of homozygous condition will reduce the time required in successive backcrosses to obtain a desired character and thus greatly increase the efficiency of the breeding process.

Crosses are now being made between haploids of *S. tuberosum* and *S. andigenum* with the cultivated diploids *S. phureja* and *S. stenotomum* in the hope that this will provide a more rapid means of improving the diploid species as well as a new source of genetic material.

A total of 1,367 lines was selected in 1960 to be planted in the crossing block for further observation and genetic studies.

MULTIPLICATION AND REGIONAL TRIALS OF HYBRIDS

In the collection of hybrids for preliminary multiplication, 36 were returned to the crossing block for further genetic improvement because of low yield or lack of other desirable agronomic characteristics. Twenty-five new hybrids were incorporated into the hybrid collection for preliminary multiplication. A total of 80 hybrids is now in multiplication.

Twenty-one hybrids in preliminary multiplication were included in a yield test for comparison with four standard varieties. Two hybrids (54-699-2 and 54-448-5) were outstanding in yield, in resistance to late blight, and in other agronomic characteristics at Tibaitatá. These hybrids will be planted in

Hybrid potato seedlings being sown in the greenhouse for later transplanting in the field.

regional trials to determine their acceptance by farmers.

All of these hybrids are being tested at other experiment stations in Colombia. At the Obonuco station in Pasto, two hybrids (53-110-13 and 52-8-16) have been selected for multiplication and regional trials. The variety Diacol-Cumbal has been released to farmers in this region and 17,580 kg. of seed were planted with the Caja Agraria for multiplication and distribution to farmers.

At the La Florida station in Popayán, the Dutch variety Alpha is being grown and small quantities of seed have been distributed to farmers at the lower altitudes (1,800-2,000 m.). At the higher altitudes (2,000-2,800 m.) the variety Diacol-Monserrate is better adapted and produces better yields. In a study of the problem of seed production in this region, it was found that seed could be produced at any elevation provided infection from virus diseases could be controlled. When seed produced at various elevations was planted in a randomized yield test at the experiment station, there were no significant differences in yield. At the higher altitudes the hybrids 53-72-1, 53-110-13, and 53H-1-195 produced superior yields in comparison with the commonly grown varieties and were more resistant to late blight. At the lower altitudes the hybrid 52-44-12 appears to be superior to the variety Alpha. These hybrids are being multiplied for distribution to farmers in the area.

At the La Selva station in Rionegro, the hybrid 53-110-13 has also given superior yields and has shown greater resistance to disease. In regional plantings with farmers this hybrid has shown a greater resistance to brown rot (*Pseudomonas solanacearum*) than the common varieties being grown. Approximately 80 tons of seed of this hybrid were distributed to farmers in the region in 1960.

SPROUT INHIBITORS

Previous experiments with the use of sprout inhibitors for the storage of potatoes have indicated that chloro IPC is more effective for the control of sprouting than other materials. A storage experiment was initiated using three concentrations of chloro IPC (1%, 2%, and 4%) on three varieties of potatoes (Guadalupe, Tocana blanca, and Alpha) for a period of five months. The results indicate that a 2% concentration of chloro IPC is adequate for the control of sprouting under normal temperature conditions in the Savannah of Bogotá.

The treatment of tubers with chloro IPC inhibits sprouting of all varieties for a longer period of time but losses due to rotting and dehydration are dependent on the condition of the variety when placed in storage and on the inherent storage ability of the variety. The storage of all the varieties tested is improved by treatment with chloro IPC, however; varieties which are normally resistant to storage losses without treatment show a greater reduction in the amount of loss when treated with chloro IPC.

INTERNATIONAL COOPERATION

Agronomists from other countries of Latin America have visited Colombia to observe the operation of the potato program and for study and training. Two agronomists from the University of Quito, Ecuador, worked and studied in the potato program for a period of six months and have returned to Ecuador to organize a program of potato improvement in that country.

Seed multiplication plots.

The director of the potato program of the Ministry of Agriculture, Maracay, Venezuela, and his field assistant visited the potato program in Colombia. The field assistant remained for a period of two weeks to obtain practical experience in seed production and control of virus diseases.

True seed and tubers have been sent to various organizations in South America and the United States. True seed of 17 hybrids was sent to the Department of Horticulture, University of Minnesota, for studies on field resistance to late blight. Tubers of 14 haploids of *S. andigenum* were sent to the Potato Introduction Station, Sturgeon Bay, Wisconsin. Tubers of 135 hybrids selected for resistance to late blight were sent to the Department of Agricultural Research in Chile. The University of Quito, Ecuador, requested 65 clones of various wild species, 80 varieties of *S. andigenum*, 37 of *S. tuberosum*, 15 of *S. phureja*, and 95 selected hybrids for genetic studies and field screening for resistance to late blight. The Faculty of Agronomy of the University of Manizales, Colombia, received various hybrids and wild species for genetic studies. About 0.5 ton of seed of two of the more promising hybrids was sent to Venezuela.

Isolation block of inbred lines of forage sorghum.

Pasture and Forage Crops

Investigation on pasture and forage crops continued in the general areas of introductions and collections, evaluation of grass and legume species in small plots under different management methods and grazing conditions, studies related to plant pests and diseases, and grass and legume breeding. Cooperative experiments included trials with the soil science, animal industry, plant pathology, and entomology sections. Work was initiated at the Turipaná experiment station, near Cereté, Córdoba. Investigations are now in progress at eight experiment stations which represent elevations from 50 to 2,700 meters above sea level. An accomplishment which assures continuity in the fields of investigation was the preparation of standardized outlines and formulation of projects and subprojects.

ALTITUDE AND PLANT GROWTH

The observations made in the introduction gardens have shown that species habit of growth may be altered at different altitudes. In general, plant height and the number of tillers of the warm climate grasses are reduced when they are grown at high elevations. The *Sorghum* species, when grown below 1,500 meters, may reach a height of 3.0 meters at maturity but at 2,200 meters they seldom exceed 1.2 meters. Rhodesgrass (*Chloris gayana* Kunth.) at the lower elevations develops a large number of upright and some semi-erect stems but at 2,500 meters the plants assume a stoloniferous habit of growth. Such distinct modifications in morphology have not been noted for the cool climate grasses which were grown at lower elevations.

A very striking alteration has occurred with alfalfa varieties of the hardy or frost-tolerant type. At the lower elevations, below 2,200 meters, the varieties of the hardy and nonhardy or frost-susceptible types developed in a similar manner, i.e., upright and elongated stems were formed throughout the year. Above 2,500 meters the morphological characteristics were the same during the rainy season, but as the dry period progressed the plants of the hardy varieties assumed a rosetted appearance and entered a semi-dormant condition, even though the day-length did not change. Growth was severely restricted and forage yields were about one-third those of the nonhardy varieties. The habit of growth of the latter was not changed.

This response can probably be explained on the basis of the photoperiod-temperature requirements of the hardy types. These varieties were selected under conditions of a long summer and short winter day-length. Thus, genotypes were chosen which develop top and root growth under a long photoperiod. With the approach of shorter days and cooler temperatures the plants enter a dormancy which produces a rosetted type of plant.

These responses to short photoperiod and low temperature are possibly controlled by two distinct stimuli. Apparently at the low elevation in Colombia the alfalfa plants receive sufficient heat units to inhibit the expression of the photoperiodic effect. This also occurs at the high elevation during the rainy season when the night temperature remains above 42°F. During the dry season, and with lower diurnal temperatures, fewer heat units are accumulated. This permits the expression of the rosetted type of plant development brought on by the short day.

These data are of practical as well as academic interest. For example, all alfalfa seed must be imported into Colombia and as a result of these observations positive recommendations can be made in regard to the best-adapted varieties. Similar results have been obtained with red and white clovers and with English ryegrasses which have been developed in the more temperate regions.

Renovation of Old Pastures

There are approximately 27 million hectares of grasslands in Colombia and of these about 90% are unimproved. In some instances pasture output is meager and 5 hectares are needed to support 1 animal unit. Experimental results have demonstrated that pasture improvement is best obtained by destroying the old sod, planting and harvesting several cultivated crops, and then seeding a grass alone or in mixture with an adapted legume. This system involves a definite rotation and requires more time than other methods of renovation; however, it permits the utilization of reserve nutrients not used by the cultivated crops.

FERTILIZATION OF OLD PASTURES

The simplest procedure would be to topdress the established sod. Use of nitrogen results in rapid plant growth and increases yields of grasses, provided that soil moisture is ample and other soil nutrients are not limiting factors. The data in Table 1 illustrate the influence of applied nitrogen on an old bahiagrass (*Paspalum notatum* Fluegge) sod, in mixture with carpetgrass (*Axonopus compressus* (Swartz.) Beauv.), a sedge (*Cyperus* sp.), and a *Desmodium* species. Although in this experiment the combination of limestone and phosphate was beneficial in stimulating forage yields, its value varies with soil types. It was anticipated that the legume fraction of the sward would increase with the use of calcium and phosphorus but this did not occur with the *Desmodium*. In other experiments, and at the high elevations, the percentage of white clover has increased with applications of these materials. Generally, this is a delayed effect and is dependent on a generous supply of soil moisture.

TABLE 1.

Beneficial effects of topdressed fertilizers[a] on an established bahiagrass sod (2,200 m. elevation).

Limestone (ton/ha.)	Nitrogen (kg./ha.)	Yield of hay (kg./ha.) with phosphoric acid:		
		0	150 kg.	300 kg.
None	0	250	520	570
	50	1,050	1,635	1,590
4.0	0	370	710	830
	50	1,645	2,050	2,450

[a] Limestone was added six weeks before the fertilizers; nitrogen was applied after every cut; and phosphate at the beginning of the experiment.

SOD SCARIFICATION AND OVERSEEDING

If a change in the botanical composition of the sward is desired, without destruction of the sod, it is necessary to overseed or transplant other species. Several experiments have been conducted in the cooler climatic regions in which seed mixtures were broadcast over a heavily grazed kikuyu grass (*Pennisetum clandestinum* Hochst.) sward with and without sod disturbance. In general, these attempts have been unsuccessful unless the sod was first scarified. With use of a rotavator, disk harrow, or a spike cultivator to penetrate the grass cover, some soil was brought to the surface where it served as a seed-bed. When this operation was performed during the rainy season, and soil moisture was plentiful after seeding, the oversown grasses (ryegrass and orchardgrass) and legumes (red and white clovers) became well established. It was found that a dressing of complete fertilizer aided in the early growth of the pasture seedlings.

At the lower elevations in the warm climate, stolons of pangola grass were transplanted into an old micay grass, *Axonopus micay* (Fluegge) Hitch., pasture without disturbing the sod and into furrows opened at 1-meter intervals. The pangola became established in both treatments, but growth was more rapid when the stolons were placed in the rows. Pasture output was more than doubled because of the pangola. The experimental sites were topdressed with increments of nitrogen, phosphate, and potash at the time of transplanting but these did not alter the development of the grass. Other experiments have substantiated the conclusion that grasses which are propagated vegetatively do not benefit from fertilizer treatments given at the time of establishment.

Supplemental Water

Output of improved pasture and cutting crops can be maintained at a high level during the rainy season, but with the onset of the dry period plant growth declines and may cease altogether. Studies have been made under the natural climatic and edaphic conditions, and as modified with supplemental water during the dry season. At the Palmira station (1,000 meters elevation) a pangola grass experiment was cut six times in an 18-month period without irrigation. When water was added during the dry season the same plots were harvested six times in a period of 12 months. In an alfalfa experiment it was possible, with irrigation, to make 10 cuts in one year and to remove 30 tons of hay per hectare; whereas without additional water the alfalfa was harvested two times and produced 3 tons. Yields were slightly lower during the dry months than during the rainy period. This probably was the result of more rapid evaporation and transpiration, lack of a precise irrigation schedule, wider fluctuation in soil moisture supply, and greater variation in day and night temperatures.

At the higher elevations (Tibaitatá and Obonuco stations, 2,650 meters), the plants of grass-legume mixtures benefited from supplemental water and forage yields were higher. With adequate soil moisture the legume fraction of the sward was maintained at 40% to 50% and plant growth of the grasses and legumes continued during the dry months. On the nonirrigated plots the white clover died after the second dry season and the red clover population was reduced to less than 10%. During the dry season the grasses became brown in color and stopped growing. Many plants died but some survived and growth was resumed (but delayed) when the rains began.

The average forage yields from the irrigated treatments were about the same during the rainy and dry periods (2.5 to 3.0 tons/ha. of dry matter at each harvest). Without irrigation yields ranged from 60 to 250 kg./ha. The intervals between cuts varied considerably, from 30 to 50 days during the latter part of the rainy period and from 70 to 100 days during the dry months. No doubt the same factors which altered plant growth at the lower elevations also affected it at the higher altitude, but the most influential factor was the wide fluctuation in day and night temperatures. In some instances the air temperature reached 85°F. at midday but dropped to 32° or lower in the early morning. Under the low temperature conditions, cell metabolism was practically inhibited until the temperature exceeded 40°F. During the rainy season the night temperature seldom was below 45°F. Thus the physiological activity within the plant was not adversely affected.

These data demonstrate the benefit obtained from supplemental water for stabilizing forage growth during the dry periods. They also indicate the need for additional studies related to soil, water, and temperature relations, especially the time of application and efficiency in utilization of applied water. A number of experiments have been initiated in collaboration with the soil science section to investigate such factors.

GRASS AND LEGUME BREEDING

RYEGRASS

Studies were continued for the evaluation of progenies obtained by various methods of breeding: intra- and interpopulation crosses; open-pollination in a polycross block; mass selection; and self-pollination. The tests are located in two different environments. Data taken on seedling vigor, forage weight, and tolerance to rust and leaf spot have shown that considerable differences exist among the progeny lines. The material will be further evaluated for seed production and plant longevity before recombining the parental clones for a recurrent cycle of selection.

Within a nursery of spaced plants it has been observed that plants of H-1, an Australian short-term rotation variety obtained by crossing domestic and English ryegrasses, yielded high quantities of forage, were long-lived, produced some seeds, but were all susceptible to rust. These results indicate that such crosses should be made between plants of these two species which have been selected for rust resistance and possess desirable agronomic characteristics. By selection within segregating populations it should be possible to find material more persistent than the domestic ryegrass, with higher forage and seed yields than the English varieties, and with disease resistance.

RESCUEGRASS

Individually spaced plants within a source nursery differed for such characteristics as seedling vigor, habit of growth, tillering, leafiness, forage and seed yield, and tolerance to rust, a leaf spot, and smut. Plant morphology varied through types from low-growing with sparse foliage and no seed stems, to very tall-growing with dense foliage and many stems that produced a large quantity of seed. The existent variation will permit ample opportunity for selection toward a type which grows rapidly during the early plant establishment period, has high forage and seed yield and disease resistance, and is long-lived.

Fifty plants of three distinct types have been selected for: low seed yield, rather sparse forage, and late maturity; medium seed yield, heavy forage, and medium maturity; and high seed yield, tall-growing, with good forage and early maturity. In the improvement program these types will be evaluated for forage yield, disease resistance, and seed yield by use of the pedigree method of selection, recurrent selection, and mass selection among a random population. In addition, selections for high and low seed yields will be made within each class and for each generation. The recurrent method will be used to study the variation in the original populations and the progress which can be expected following this procedure.

FORAGE SORGHUM AND SUDANGRASS

Inbreeding was continued among lines and varieties, and rather uniform material has been obtained after four to five generations. A number of lines were recombined in the F_4 generation and several appear to have high resistance to lodging, good forage and seed yield, and tolerance to diseases. Some lines of sorghum with high disease resistance have been obtained but these plants have dry stems, an undesirable characteristic for green chop feed or silage. Crosses will be made between plants with dry and succulent stems in an attempt to recombine this factor with disease resistance.

IMPERIAL GRASS

Two clones with high field resistance to "gummosis," a bacterial disease, are being propagated for regional testing. In the past, only vegetative material has been evaluated in the search for disease resistance, since plants could not be grown from seeds under normal conditions of germination. A technique has now been perfected for germination and growth of seedlings which develop into mature plants, and studies are being initiated by the collaborating plant pathologist to compare seedling and mature plant response to inoculations with bacterial suspensions. If this is fruitful, large populations of young plants can be evaluated, with increased probability of finding disease resistance.

RED CLOVER

Seeds have been harvested from a polycross block of 100 plants selected for high forage yield, disease tolerance, and persistence. Since the clones did not flower uniformly under field conditions and some developed more seed heads than others, pollination was non-random and seed yields were variable. The clones have been moved into the greenhouse and the photoperiod extended to 18 hours to stimulate more uniform flowering. The plants will be mass sibbed by hand. By such means, more random pollination will be obtained and higher seed production of some clones will occur. The plants will be progeny tested for general combining ability, using the seeds from the field and greenhouse.

BIRDSFOOT TREFOIL

About 25% flowering has been obtained among individually spaced plants from a Brazilian variety. The plants with seed heads were chosen for a recurrent cycle of selection but a large number did not survive cutting, and those with the highest seed yields were killed or recuperated rather poorly. It has therefore been decided that longevity should be made a major objective in the breeding program, in addition to forage and seed yield. The plants will be cut several times and the survivors which yield seed will be used as the base material in subsequent selections.

A nursery of birdsfoot trefoil plants at Tibaitatá.

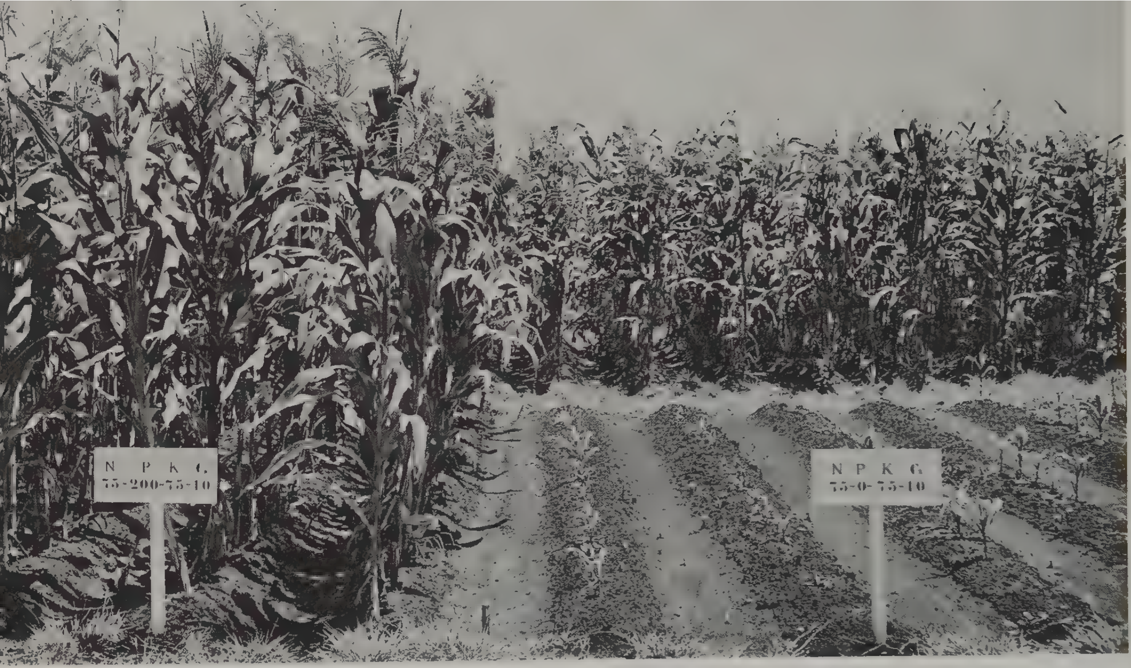
PASTURE GRAZING TRIALS

Grazing trials, in cooperation with the animal industry section, have been initiated at the Tibaitatá and Palmira experiment stations. A "put and take" system is being used whereby the number of animals on a given pasture is adjusted according to the pasture output. With trials of this type the animal husbandryman supervises the animals (milk or meat production records) and the agronomist is responsible for pasture management and forage production records. Each week these technicians decide whether an animal should be removed or added to the pasture. To aid them in making this decision, small areas were clipped every week from the pastures, forage yields recorded, and the proper calculations performed to arrive at the theoretical carrying capacity. After several weeks, good correlation was achieved between the estimated number of animals per pasture and that calculated by the clipping technique.

TRAINING PROGRAM

One agronomist received a Master's degree at the University of Florida and returned to continue work in the pasture and forage crops program. Three others are pursuing advanced training at universities in Oregon, North Carolina, and Georgia. Students from the three schools of agronomy in Colombia worked during vacation in the forage crops sections at three experiment stations and several completed cooperative investigations which served as thesis studies in partial fulfillment of the requirements for their degrees.

One agronomist and the director of the program lectured at a pastures short course held at the Palmira Faculty of Agronomy, and two agronomists taught courses at the Medellín Faculty of Agronomy. The annual conference was held at the Palmira experiment station, where results were reviewed and future trials discussed. A visit to nearby farms permitted the agronomists to see the practical application of experimental results. On one dairy farm it was observed that animal-carrying capacity on pangola grass (*Digitaria decumbens* Stent.) has been tripled by utilization of recommended grazing, irrigation, and fertilizer practices.



Certain of the cold-climatic soils of Colombia are extremely deficient in phosphorus.

Soil Science

The soil science section since its inception has had the over-all objective of improving crop production through the proper use of fertilizers and through good soil and water management practices. Although this goal has remained constant, the means of achieving it have been gradually modified as the program has developed. Since further modifications are anticipated, a brief review of the history of each project and an outline of plans may be more informative than the presentation of isolated findings alone. In addition to the four main projects, a separate section on laboratory facilities is included.

Efficient Use of Fertilizers

The initial approach of the soil science section in Colombia was to undertake a rapid screening of fertilizer needs of the principal crops through simplified field experiments. These were supported by greenhouse tests of soils from outlying agricultural areas. In this manner the principal fertilizer requirements in important agricultural zones were rapidly outlined. In 1956 it was possible to state in broad terms the apparent nitrogen, phosphorus, and potassium needs in the low, hot valley of the Sinú, the somewhat higher Cauca and Medellín Valleys, and the high, cool Savannah of Bogotá and surrounding mountains. Subsequent studies broadened the base of information to include data for the Nariño section in the south, the high plateau of the Cauca Department, and the Tolima Valley. Nearly all of the important areas for the production of corn, wheat, barley, and potatoes were thus touched in this work.

During 1960-1961 work was continued on this project on much the same basis with corn, beans, barley, wheat, and soybeans.

A number of short-term fertilizer experiments were conducted using designs of the response surface type. These were with corn in the Cauca, Sinú, Medellín, and Tolima Valleys and near Popayán, and with barley and wheat in the Savannah of Bogotá. The most sizable responses were to nitrogen in the Tolima Valley and to lime and phosphorus at Popayán.

Several experiments were carried out in the Cauca Valley with soybeans and with beans in the Savannah of Bogotá and at Popayán. Two of the soybean tests were installed in fields in which potassium deficiency had been suspected in a previous planting of cotton. No responses were obtained to this element or to nitrogen or phosphorus. Sizable increases in bean yields were recorded as a result of phosphorus application in the Savannah of Bogotá and to lime, as well, at Popayán.

At the present time, as noted above, it is possible to make general fertilizer recommendations for corn, small grains, and potatoes in most of the important zones in which these crops are grown. There is a need now for some specific information in which fertilizer requirements are more clearly defined and are related more closely to soil types and chemical properties.

The left-center plot received a minus-nitrogen mixture; that on the right a complete fertilizer. Responses to nitrogen are much less common than to phosphorus in the small grain growing areas of Colombia.

Long-Term Management Practices

Shortly after the initiation of fertilizer experiments a number of long-term studies of soil management practices were started. These have included comparisons of different crop rotations in several climatic zones, measurement of plant nutrient reserves in the soil through continuous cropping with small grains, corn, and potatoes, and evaluation of different procedures for handling crop residues.

The results of studies of this type are usually not clearly defined until the treatments have been continued for several years and cumulative effects have come into play. Perhaps for this reason differences measured in 1960-1961 were much larger in several experiments than had been found earlier.

At Palmira the omission of nitrogen from continuous corn plots resulted in a significantly lower yield for the first time in ten consecutive plantings. Without added nitrogen, yields were approximately 70 bu./acre as compared with about 90 bushels with nitrogen applied. The omission of phosphorus or potassium did not measurably reduce yield in this test.

In another experiment at Palmira, continuous corn is being compared with corn in rotation with soybeans and alfalfa. Yield differences due to the legumes were measured in the fourth corn crop in the 1960 A or first semester. Corn in rotation with soybeans yielded about 25 bu./acre more in this semester than did continuous corn. Similar differences appeared likely in the fifth crop and the general appearance of corn in rotation with a legume suggested that the difference was largely due to an improved nitrogen supply. All plots are to be split in the sixth cropping season with nitrogen fertilizer as the additional variable. It should be possible, therefore, to determine the extent to which the beneficial effect of the legume is due to an improved nitrogen supply or to other effects on soil conditions.

At the Tulio Ospina station, corn in rotation with soybeans performed but little better than continuous corn. In both cases very large responses to nitrogen were obtained. On the other hand, corn grown after a legume green manure crop produced very much better than either continuous corn or the corn-soybean rotation.

In the Savannah of Bogotá principal responses of small grains have been to phosphorus fertilizer. A typical contrast between plus and minus phosphorus is shown here.

At Tibaitatá, the tenth consecutive potato crop yielded about 50% more when a complete fertilizer was used than when either nitrogen or phosphorus was omitted. In other continuous cropping tests, the yields of wheat and barley were nearly three times as high in plots with phosphorus applied as in those not fertilized with this element.

New experiments started in 1960-1961 included a full-scale testing in the Savannah of Bogotá of the potato-wheat-pasture rotation which has appeared quite promising for this climate in preliminary trials. Soil management studies were also started at the new experiment station at Cereté in the Sinú Valley. Extensive land-leveling operations are planned for this farm and present indications are that exposure of the subsoil will present some physical and nutritional problems. The possible role of green manure crops and fertilizers in reclamation of these areas is being evaluated.

Present plans do not anticipate any great increase in studies under this project. Continued collection of data from established experiments, coupled with more intensive study of chemical and physical changes which may take place in the soil, appears desirable.

LABORATORY AND GREENHOUSE STUDIES

Greenhouse and laboratory studies have been used to interpret and extend the results of field experiments to a wider variety of conditions. Pot culture techniques in which growth responses of lettuce serve as a measure of nutrient status of soils have been most frequently used. Laboratory tests have consisted chiefly of conventional soil analytical procedures.

During 1960-1961, comparative data were obtained on several means of extracting available soil phosphorus. A group of 47 soils was collected throughout Colombia and brought to Tibaitatá, where plant growth with and without added phosphorus was measured under greenhouse conditions. Of the procedures tested to date the Olsen technique, which involves extraction with sodium bicarbonate, appears to give the best correlation with plant response to applied phosphorus. It was found that the relationship between amounts of phosphorus extracted by this procedure and crop response in the greenhouse was different for soils from the warm and cool climates (Figure 1). Since greenhouse conditions were identical for all soils, these differences must have been related to inherent soil characteristics. In general, a lower level of extractable phosphorus proved to be adequate in soils from the warmer climates.

Preliminary evidence indicates that a high proportion of the phosphorus in these soils was present in an organic form. For the group as a whole, about two-thirds of the phosphorus was apparently organic, and in some soils as much as 90% of the total phosphorus was in this form. It was also found that soils of the cool climate frequently contained a greater amount of total carbon in relation to the organic phosphorus level.

These two findings, if verified, could have some important implications concerning probable crop responses on Colombian soils. Crops grown under cultural systems or in climatic situations which tend to break down the organic complex would probably be less responsive to applied phosphorus during the early years than would those grown under conditions which tend to maintain or increase soil organic matter.

Soil levels of exchangeable and sulfuric acid-soluble potassium of a number of Colombian soils were measured in relation to crop removal of this element under greenhouse conditions. As much as 1,300 lbs./acre of potassium was extracted by the plants while exchangeable potassium declined by about 700 lbs./acre. The remainder presumably came from non-exchangeable sources. The sulfuric acid extraction procedure appears quite promising as a method for measuring potential potassium reserves in these soils. Declines in sulfuric acid-soluble potassium were highly correlated with potassium removal by plants and accounted for essentially all the potassium found in plant material.

Increased emphasis on this project should be anticipated. It is clear that at least a part of the information obtained from soil studies in the temperate zones must be modified if it is to be applied to the tropics. Many of these relationships must be investigated if further advances in predicting crop responses to fertilizers are to be obtained. Improvement of laboratory facilities and training of personnel are planned. One of the Colombian agronomists of the soil section started his graduate study in soil chemistry in the past semester as a first step to specializing in this direction.

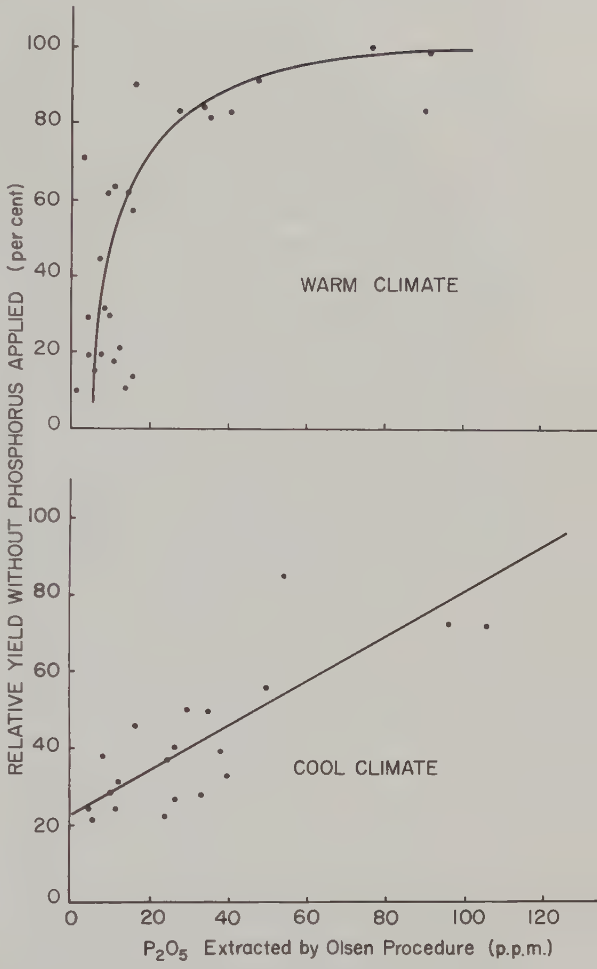


Figure 1. Relationship of soil phosphorus extracted by the Olsen procedure to phosphorus response of barley under greenhouse conditions. The soils used in this experiment were collected throughout Colombia.

SOIL-WATER-PLANT RELATIONSHIPS

In nearly all of Colombia the prevailing temperatures are such that 12-month cropping can be practiced. Rainfall is usually inadequate for at least part of the year, however, and it is clear that supplemental irrigation can be profitably employed. The decision to emphasize water utilization studies was made in 1958 following a general review of the soil science program.

During the 1960-1961 dry season three irrigation × fertilization experiments with potatoes were established at Tibaitatá at 30-day intervals. Large responses to water were obtained in two of the tests, but there were no responses to fertilizer. Typical results were a production of 20.5 tons/ha. of potatoes without irrigation, 27.5 tons with irrigation only after two-thirds of the available soil water had been removed, and 40.4 tons when the soil was not allowed to lose more than one-third of the available water.

At the Obonuco station in Nariño, potato yields were increased by nearly 50% through the use of irrigation. Responses to nitrogen were measured in this test and the improvement in yield due to nitrogen was somewhat greater on the irrigated than on the nonirrigated plots. In view of the known high fertility of soils at this station and at Tibaitatá, however, it cannot be concluded that any real evaluation of irrigation × fertilizer interactions has been made.

Collection of evapotranspiration data has continued at Palmira and a new unit has been installed at Tibaitatá. No further installations will be made, however, except in situations where large borders may be provided to minimize microclimate effects.

As of September, 1960, this country-wide project has been in the hands of one of the Colombian agronomists who took his Master's degree in the United States with a specialty in soil physics. Equipment has been obtained to permit the installation of a fairly complete soil physics laboratory at Tibaitatá. When this laboratory is in full operation it is expected that the entire irrigation program will be rapidly expanded. The laboratory should also contribute to other phases of the soil program, such as measurement of the effects of crop rotation on soil structure.

LABORATORY FACILITIES

Facilities of the soil science section have included two chemistry laboratories, one at Tibaitatá and one at Palmira. Each of these has been staffed with two trained chemists plus one or more assistants. Each laboratory has been responsible for routine analyses of soil and plant samples collected at the station and at one or more of the nearby substations. During the past year steps have been taken to divide responsibilities for routine analyses so that all plant samples will be run at Tibaitatá and all soil samples will be handled through Palmira. Additional supplies and equipment to increase the efficiency of each operation are being obtained as needed.

Plans for Tibaitatá call for a daily capacity of 24 samples analyzed for nitrogen, phosphorus, potassium, calcium, and magnesium. Existing facilities will permit increasing the daily output to perhaps 48 samples if necessary. It is expected, however, that development of routine analyses for micronutrients may prove more useful to the program.

Initially the Palmira laboratory will undertake determination of exchange capacity, exchangeable bases, pH, organic matter, total nitrogen, and available phosphorus. Additional determinations may be made routine as required. The chemist in charge at Palmira is presently at North Carolina State College for three months where he will study procedures used in a large-scale soil testing operation. Certain of these techniques for maintaining accuracy and high output should be useful in the Palmira laboratory.

No decision has been made to develop a soil testing service for farmers under the direct supervision of the soil section. There is interest on the part of some farmers for such help, however, and several agencies are either offering this service or seriously considering doing so. Soil tests, although of value if properly used, can be quite misleading if their definite limitations are not recognized. Consequently, the soil section should probably take an active part in this matter. Should it appear desirable at a later date to form a program of this sort the Palmira laboratory will provide a strong nucleus from which to develop.

Studying stem rust of oats, Tibaitatá.

Plant Pathology

WHEAT, BARLEY, AND OATS

Two sections of the greenhouse at Tibaitatá are now equipped with "Floral Breeze" units which cool by water evaporation. Maximum temperatures are controlled with these units, but minimum temperatures are not. In addition, three Percival Growth Cabinets have been recently installed in which temperature, light, and, to some degree, humidity can be closely controlled. With these facilities, identification of rust races can be made with precision and confidence.

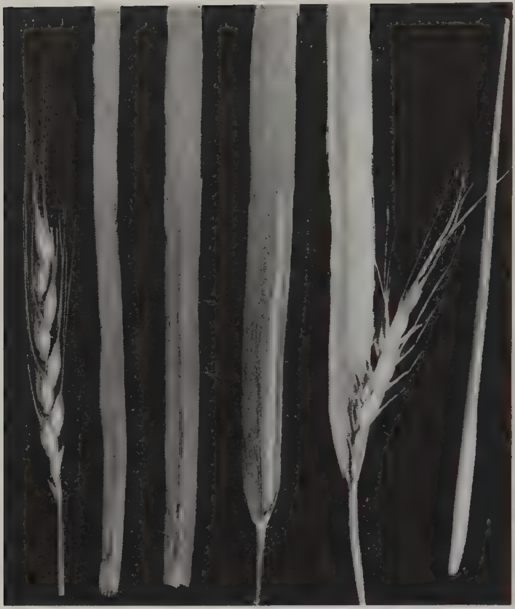
Of 223 collections of stem rust of wheat (*Puccinia graminis* var. *tritici*) studied in the past year, 19 distinct races were identified. Race 28 and the race-group 6-178 comprised 41% and 43%, respectively, of the collections identified. The remaining 16% consisted of 17 others including the virulent race 15B. None of the 223 collections was capable of attacking the varieties Bonza and Nariño.

Eight races, including 30 subraces, were identified in a total of 148 collections of stem rust of oats (*P. graminis* var. *avenae*) studied. These races are capable of attacking all known sources of resistance, including the highly resistant variety Saia.

Studies of rust collections made from native and introduced grasses indicated that the grasses are important as a host on which rusts survive or over-season, and that they serve as an important source of inoculum and possibly a source of new races of the cereal rusts. These factors are especially significant in regard to the development of *P. graminis* var. *avenae*.

Studies were continued on the epidemiology of rust disease, the use of fungicides to control rust diseases, the deterioration of stored grain, and the influence of the geographical origin of cereal seed on subsequent yield and disease reaction.

Studies were also continued on the dwarfing disease "enanismo" of cereals which occurs in the Department of Nariño. The tests confirmed previous results indicating that the disease is caused by a virus which is not transmitted in the soil, through the seed, by



Left to right: healthy spike of wheat, healthy wheat leaf, leaves and spike of wheat infected in the greenhouse with hoja blanca of rice.

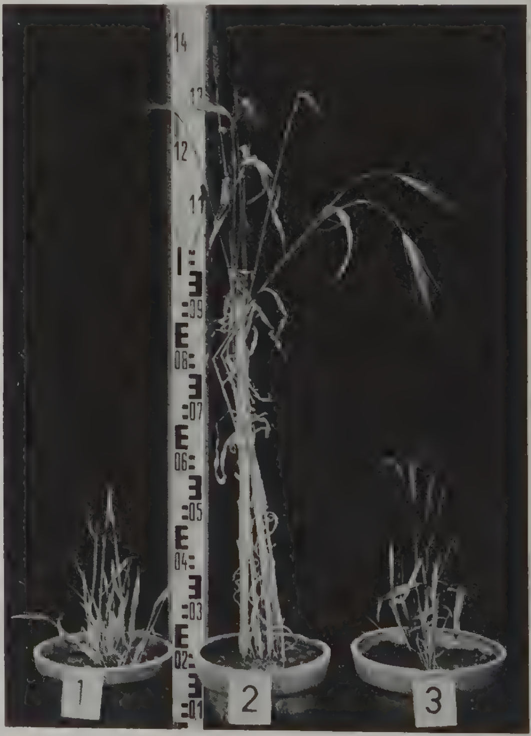
mechanical means, or by aphids. Individual leafhoppers of the species *Cicadulina pastusae* have been repeatedly shown to be capable of transmitting the virus.

POTATOES

In 1960-1961, experiments were continued on the nature of partial resistance of potatoes to *Phytophthora infestans*, the causal agent of late blight of potatoes. The results confirmed previous observations that there is a positive correlation between a high degree of partial resistance and low sporulation, an increase in time of sporulation, small size of lesions, and a reduced number of lesions produced by a uniform quantity and concentration of inoculum. This has been demonstrated in both the laboratory and the field. The entire potato collection (over 1,500 clones) of the species *Solanum andigenum*, *S. tuberosum*, and *S. phureja*, and various hybrids and wild species were tested in the greenhouse and the field to determine their genotypic reaction for resistance to races of *P. infestans* and their degree of partial resistance. This information is essential for the breeding program in work to obtain a higher degree of resistance to *P. infestans*.

Eleven fungicides were tested in cooperation with the potato section to evaluate their control of late blight. This test, plus those made in the past, provides a sound basis on which to make recommendations to growers on the most efficient and economical use of fungicides.

A test made in 1959-1960 showed that growers could save considerable time and expense by spraying after a fixed amount of cumulative rainfall. This test was repeated in 1960-1961 and substantiated previous results. By spraying potatoes after 25 mm. of accumulated rainfall, control equal to that given by spraying once a week was obtained. Twelve sprays were applied when spraying was done at weekly intervals, a common practice in Colombia, while only four were required when spraying was done after 25 mm. of ac-



In a study on "enanismo," barley (1) and wheat (3) were caged with a single insect, *C. pastusae;* the control (2) was caged without insects.

cumulative rainfall. In practice, this latter method of spraying could save Colombian growers considerable time and money.

The brown rot disease of potatoes, caused by *Pseudomonas solanacearum*, which caused considerable economic loss in 1959, has been studied at Tibaitatá. Its characteristics in biochemical and physical tests are similar to those described in the literature. Over 20 known hosts of this pathogen were inoculated to determine its host range. Studies on its ability to cause disease at different temperatures indicate that the bacterium isolated at Tibaitatá may be a strain capable of causing disease at temperatures lower than those previously reported.

FORAGE CROPS

The plant pathologist working on cool climate forages at Tibaitatá has continued studies on methods of testing lines of white and red clover for resistance to a root and stem rot complex. Both field and greenhouse tests for resistance are in progress. Notes of the occurrence of various diseases in the field have been taken in cooperation with members of the forage program.

Several species of rust are serious on grasses in cool climates. Collections of rusts were made from six grass species and used to inoculate ten species of grasses. The reactions gave valuable information for the determination of rusts responsible for field infections. This work will be continued, since it is important not only to the forage program but also to the small grains program.

During 1960 diseased plant material collected in the Departments of Cundinamarca, Nariño, Boyacá, and Valle was studied. Over 20 disease-causing organisms were identified from this material. This information is valuable in evaluating the relative importance of forage diseases in Colombia.

The disease "gummosis," caused by *Xanthomonas axonoperis*, of Imperial grass and micay is the major project of the plant pathologist at the Medellín station. Over 120 collections of these grasses from various parts of Colombia have been tested in both the laboratory and the field for resistance to the disease. Fifteen of the collections have an acceptable degree of resistance, but none is completely so. It has been demonstrated that certain of the resistant clones do well when planted in farmers fields. The resistant clones are being increased for future distribution.

The Colombian Potato Collection, planted to study resistance to late blight. The variety Algodona (foreground) shows a high degree of partial resistance.

In addition to testing clones for resistance to gummosis, studies have been made on more effective methods of inoculation, obtaining plants from true seed, conservation of inoculum, survival of the bacterium in the soil, cultural methods of control, and possible agents of transmission.

CORN

Routine tests of the resistance of corn lines to stalk and ear rots caused by *Diplodia zeae* and species of *Fusarium* were continued at Palmira and Medellín. Some of the better lines of corn were tested for resistance to *Helminthosporium turcicum* at Medellín. A new and simpler method of producing inoculum by the utilization of dried macerated leaves from infected plants, has been found to be as effective as the older method of producing spores on artificial media.

Studies on the deterioration of stored corn were made with samples from Tulio Ospina, Palmira, and Montería. A high moisture content of the seed plus storage molds were found to be the most important factors contributing to the deterioration of seed. *Aspergillus restrictus*, *A. repens*, and *A. amstelodami* were the most frequently encountered storage molds. Seed stored in paper bags at room temperature and humidity at Tulio Ospina and Palmira, where the relative humidity is below 70% most of the year, had good germination after as long as 32 months in storage, while similarly stored seed at Montería, where the relative humidity is above 75% most of the year, did not germinate after 12 months in storage and was heavily infected with storage molds.

MISCELLANEOUS

Only the major projects of the plant pathology section are treated in this report. During the past year, the section also investigated or gave advice on disease problems of beans, tomato, bananas, vegetables, and other crops. The plant pathologist of the cotton institute spent six months with the section, and an extension specialist in plant pathology is currently in training.

Entomology

The greater part of the work of the entomologists during the past year was a continuation of previous studies. The return of two entomologists from successful completion of advanced studies in the United States permitted the enlargement of some previous projects and the initiation of new work. Contact of the research entomologists with extension was broadened by the assignment of an extension entomologist of the Division of Crops to the section for a period of orientation and training.

Laboratory facilities were improved at Tibaitatá, Palmira, and Obonuco and the storage space and facilities for the studies of stored grain insects were increased at Palmira during the year.

The reference collection of insect pests was increased in numbers by the acquisition of about 50,000 specimens, and in value by the reception of about 1,000 species that have been identified by cooperating specialists.

The special study on the genus *Sogata* (vectors of the hoja blanca disease of rice) was completed and published during the year, and the review of the genus *Cicadulina* (including the vector of the dwarfing disease of barley, "enanismo," *Cicadulina pastusae* Rup. and DeL.) was well advanced. The study of the seasonal abundance of the budworm of corn, *Laphygma frugiperda* (J. E. Smith), was also concluded. In this study, it was found that the budworm is abundant in young corn (before the start of tasseling) and that the populations of the pest are highest during wet seasons. From preliminary studies, it appears that *Cicadulina pastusae* is most abundant during the dry seasons, that this species is restricted to the cooler zones (roughly, above 2,000 m. elevations), and is replaced in the warmer regions by the related species *C. tortilla* Caldwell.

The study of the biology of the leafminer of potato, *Liriomyza* sp., was started during the year. The bacterial pathogen, *Bacillus thuringiensis* Ber., was found to be effective against several species of lepidopterous larvae including the corn budworm and the corn stalk borers, *Diatraea* spp., and also against the stored grain pests *Tribolium castaneum* (Herbst) and *Sitophilus sasakii* (Takahashi); this latter species is the "*S. oryza*" of previous reports. *B. thuringiensis* was ineffective against the cutworm, *Agrotis ypsilon* (Hufnagel).

Several as yet unidentified pathogens were also isolated from other pests; perhaps the most important of these was a fungus of the human bot fly, *Dermatobia hominis* (L., Jr.).

PESTS OF CROPS

Chemical control studies of certain pests of vegetable crops were made during the year. The leafminer of the horsebean (*Vicia faba* L.), *Agromyza* sp., was controlled in the younger plants by sprays of heptachlor, methyldemeton, parathion, and Shell WL 1650, but these insecticides did not give adequate protection to the older plants. Sprays of parathion, Phosdrin, and Trithion were very promising for the control of the complex of insects that attacks cabbages, while methyldemeton was very poor against these pests. Insecticides were also tested against the tomato pinworm, *Keiferia lycopersicella* (Busck), at Palmira; parathion proved to be the most promising of the insecticides tested in the preliminary trials.

Tests of insecticides against the leafhopper of beans, *Empoasca kraemeri* R. and M. were continued during the year. Among the newer materials that were tested, Di-syston, Phosdrin, Sevin, and WL 1650 proved to be as effective as the best of the older insecticides, while ethion failed to control this pest. In tests with commercial varieties of beans, there were again great interseasonal variations in the responses of the bean varieties to their insect pests. In a special test of selected varieties, the variety Antioquia 26 showed a much lesser number of *Empoasca* than did the others, Antioquia 5 showed practically no yield loss even though it supported a large number of this pest, and Antioquia 10 had a large number of nymphs of *Empoasca* and was severely damaged by them.

Insecticides were ineffective in protecting a susceptible variety of rice from the hoja blanca disease. Sprays of demeton, endrin, and toxaphene, however, gave appreciable increases in the yield of rice by suppressing the complex of insects that infests this crop. Except when an economically excessive number of treatments was made, sprays of DDT were also ineffective in adequately suppressing enanismo in a susceptible variety of barley. The development of the barley variety Galeras that is resistant to enanismo makes the use of insecticides unnecessary in the area affected by this disease. A leafminer of small grains, *Agromyza* sp., that had been relatively scarce in the Pasto area appeared in outbreak numbers in this region during the past year. Sprays of aldrin, DDT, and endrin gave protection against this pest in preliminary trials.

The tests of the resistance of varieties of potatoes to their common pests were continued during the year. As in previous trials, differences were found between varieties with regard to all of the pests; a review of the resistance work in potatoes is now being made. Heptachlor, one of the insecticides recommended for use on potatoes, failed to effect an acceptable control of the potato leafminer, *Liriomyza* sp., in one test at Tibaitatá; this failure is attributed to a poor formulation of the insecticide. Endrin and WL 1650 both gave excellent results against the common pests of potatoes. A complex of several species of aphids often appears in potatoes that are maturing. While rarely numerous enough to justify special treatment in commercial fields, these species present a special problem in potatoes grown for seed because they can transmit virus diseases. In special tests of insecticides against these aphids, late sprays of demeton, Hercules 3653 (an experimental compound of the Hercules Powder Company), parathion, and Trithion proved to be especially effective.

Wheat bran baits of the spores of the pathogen *Bacillus thuringiensis*, and sprays of WL 1650 or a mixture of DDT with toxaphene proved to be equal to the older materials in the control of the budworm of corn, *Laphygma frugiperda*, and also gave some control of the corn stalk borers, *Diatraea* spp. The fungal pathogen, *Beauveria bassiana* (Bals.) Vuill., was ineffective against both of these pests, perhaps because of loss of pathogenicity of the strain of the fungus used in these tests. WL 1650 is phytotoxic to corn at dosages greater than 0.25 kg./ha., but it is effective against the budworm at this dosage and its phytotoxicity in emulsifiable formulations can be reduced by the use of less toxic solvents.

The work on the relative susceptibility to the common insects of lines, varieties, and hybrids of corn was continued. As in previous years, differences were found among corns with regard to the numbers of corn budworm, the stalk borers, and the corn earworm, *Heliothis zea* (Boddie). There is a considerable mass of back data on resistance of corns to their common pests now available, which is presently being reviewed.

Pests of Stored Grains

The effectiveness of dusts of the grain protectants malathion and PBP (a mixture of piperonyl butoxide with pyrethrins) against the pests of stored beans and corn has been noted in previous reports. Removal of the unsightly residue left on the grains by these dusts requires an additional operation. Since spray formulations of these protectants are free of this defect, their effectiveness was tested during the year. The materials were equally effective against the bruchids that infest stored beans, but the sprays of malathion were more effective in protecting stored corn. A test of mixtures of the fumigant acrylonitrile with the standard fumigants, carbon disulfide—carbon tetrachloride and ethylene dichloride—carbon tetrachloride, in stored corn heavily infested with insects, failed to show any benefit from the addition of the acrylonitrile.

Pests of Livestock

The poultry section is studying the use of caged layers in Colombia. The excessive breeding of the housefly, *Musca domestica* L., in the "beds" beneath the cages of the hens presents a problem with this system. In tests at Palmira, sprays of DDT or Diazinone over the bed and the manure proved to be most effective against the larvae of the housefly; aldrin was also effective, while sprays of borax, lime, and spores of *Bacillus thuringiensis* were poor. Mixing DDT with the bed combined with occasional stirring of the bed and the manure, and surface application of Diazinone appear to be effective in practice in suppressing fly breeding in the beds.

Cabbages attacked by a complex of insect pests that lower quality and yield can be effectively controlled with well-timed applications of insecticides (see illustration, page 155).

A summary of the study of the biology and control of the human bot fly, *Dermatobia hominis*, is presented in the report of the animal pathology section.

Special Studies

The experimental work on weed-killers during the year was restricted to studies of the use of simizine as a weed-killer in corn and of various chemicals for control of nutgrass, *Cyperus* spp. In preliminary tests, simizine appeared to be superior to DNBP in controlling the weeds in corn when applied as preemergence weed-killers at Tibaitatá and Nataima. Data on the yield and possible phytotoxic residues of simizine were not taken during these trials and the tests are continuing.

Two or three applications of CMU or simizine with diskings of the land prior to each application showed promise in the control of nutgrass. Pre-emergence applications of DNBP continued to give satisfactory control of the weeds in barley, beans, corn, potatoes, and wheat at higher elevations of the country.

The study of the relationship between *Cicadulina pastusae* and the dwarfing disease enanismo of small grains in the Pasto region was greatly advanced during the year; part of this work was done in collaboration with the plant pathology section. It was found that the seedling plants were more susceptible to enanismo than the older plants; that a single insect could cause severe symptoms of enanismo after feeding on the plant for only one week; that the nymphs as well as the adults of *C. pastusae* can cause the disease; and that there is an inverse relationship between the stunting of the plant and the vein-swellings caused by the feeding of the insect. More critical studies of these relationships are in progress.

A study of the pollinators of certain leguminous crops was started late in the year with the collaboration of the pasture and forage crops section. From early observations it appears that existing populations of the honeybee, *Apis mellifera* L., and of bumblebees, *Bombus* spp., are sufficient to assure commercial yields of seeds of white clover in the regions near the Tibaitatá and Obonuco stations, and that there is considerable pollination of alfalfa by carpenter bees of the genus *Xylocopa* at both Nataima and Palmira. Insects that serve as cross-pollinating agents in birdsfoot trefoil and red clover have not been noted to date.

The native Romosinuano breed has excellent characteristics for beef.

Beef Cattle

The livestock industry, with the exception of coffee, is the most important agricultural enterprise in Colombia. It is estimated that 30% of the national income is derived from beef cattle alone.

According to the most recent reports, the national income in 1959 from animal and plant agriculture was 7,780,800,000 pesos, and of this total the return from beef cattle was 1,268,300,000 pesos. This figure does not include data from the Llanos region, where it is reported that income from beef cattle is equal to that from the rest of the country.

The cattle population in Colombia is said to be 14,900,000 head, which is 13th in the world for cattle numbers. Of this total, 2.5 million are in the Llanos and 1 million in the Río Sinú Valley. It is estimated that each year 100,000 fat steers are shipped from there to the interior for slaughter.

The greater part of the beef production is located in tropical areas. It is stated that the total investment in beef cattle, land, and facilities for the beef cattle industry is 10,187,360,000 pesos.

Existing data indicate that the average per capita consumption of beef is 28.85 kilograms. This figure is low, even though the ration of one beef animal per person is high, when compared with other areas of the world.

ANIMAL MANAGEMENT

By definition, management is adequate feeding practices, selection, improvement, sanitation, and efficient and economical production. This is the most important field in beef cattle production, because when well executed it brings about a profit to the cattleman.

During 1960, management systems were standardized in most of the sections of the beef cattle program. The results of this work are presented elsewhere in this report.

ANIMAL NUTRITION

PALMIRA

During 1959, a grazing experiment was started in which the nutritive value and carrying capacity of four grasses were studied. Forty crossbred Cebú steers were randomly assigned to eight lots of five steers each for the

The typical Llanos steers are small and slow growing but provide a large amount of Colombian beef.

evaluation of pará, puntero, pangola, and Guinea, the grazing grasses most adapted to this region. During the first 196 days of the experiment, neither irrigation nor fertilizers were applied, but during the final 112 days both water and fertilizers were applied to all pastures.

The put-and-take system of animal management was followed in so far as possible. Body weights were recorded every 28 days, as well as the consumption of salt, mineral mix, and grain supplement in certain lots during the second phase of the experiment. The animals in replication 1 were implanted with a commercial female hormone compound.

The steers on puntero pasture during the first 196 days produced more beef per hectare and had a higher average daily gain, but a lower number of animal days, than those on either pará or pangola. The average daily gain on pangola of 0.45 kg. per head was the lowest for all treatments during the first part of the experiment. However, during the second part of the experiment, with irrigation and fertilizer added, the average daily gain was about equal for all lots, but carrying capacity on puntero was lower than on the other grasses. The protein content of the grasses greatly influences average daily gain, and this may well be one of the principal limiting factors in steer fattening on grass in Colombia.

Steers with female hormone implants had a higher average daily gain than those without hormone and gave a net return of 21.12 pesos more per head upon completion of the experiment.

Grain supplementation produced a net return of 10.60 pesos more per head over non-grain-fed steers.

There appears to be a synergistic effect of grain and hormones, and steers which received both produced the best gains. However, grain alone was superior to hormone alone, an indication that for beneficial effects of hormone treatment, nutritional level must be optimum.

In a second experiment in animal nutrition, 32 crossbred Cebú steers were randomly assigned to eight lots of four steers each. Treatments consisted of corn silage alone, corn silage plus supplement, sorghum silage plus supplement, and green chopped sorghum plus supplement. The steers on replication 1 were also implanted with female hormones. Body weights and feed consumption were recorded every 28 days.

Gains in all lots were not satisfactory. However, the steers that were fed corn silage plus supplement gained 0.74 kg. per day during a 196-day experiment. Steers on corn silage alone gained 0.32 kg. per day during the experiment.

MONTERIA—TURIPANA

A steer fattening experiment on pasture was conducted comparing Romosinuano, Costeño con Cuernos, and crossbred Cebú steers. Forty steers of each breed, grouped in so far as possible according to age and weight, were placed in one 80-hectare pasture. Half the steers, 20 of each breed, were implanted with female hormones. During the experiment, all of the animals received iodized salt and a commercial mineral mix free-choice. The animals were weighed the day the experiment began and at intervals of 28 days during a 168-day experimental period.

The average daily gain of the steers of each breed was inversely proportional to the average body weight of each group. Romosinuano steers with an average body weight of 478.9 kg. had an average daily gain of 0.49 kg., while Cebú steers with an average body weight of 336.1 kg. showed an average daily gain of 0.74 kg. The Costeño con Cuernos steers were intermediate, with an average body weight of 380.9 kg. and an average daily gain of 0.59 kg. It is to be stressed that the Romosinuano steers reached 478.9 kg. at an average age of slightly over 24 months while the average age of the other two breeds was considerably greater.

LA LIBERTAD

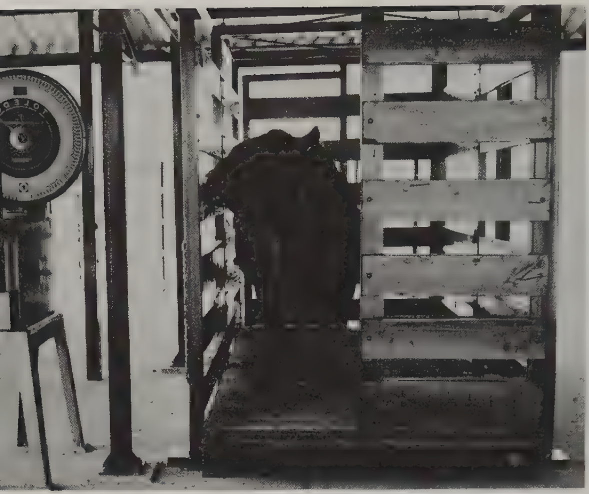
A steer fattening experiment on pasture was conducted at La Libertad comparing steers of the Sanmartinero and Casanare breeds. A total of 100 Casanare and 30 Sanmartinero steers was used in the experiment. Half of each breed were implanted with female hormones. One hectare of pasture was given for each steer in the experiment, and all four of the experimental groups were always maintained in one pasture. During the experiment a salt and mineral mixture was given free-choice. The steers were weighed at the beginning of the experiment and at 28-day intervals during a 168-day experimental period.

The Sanmartinero steers gained an average of 47.0 kg. with an average daily gain of 0.52 kg. during the experiment, while the Casanare steers gained an average of 41.0 kg. and produced an average daily gain of 0.43 kg. The Sanmartinero steers, which were about 18 months younger in age, reached an average body weight of 415 kg., while the Casanare steers weighed only 353 kg.

Average daily gain of the hormone-implanted Sanmartinero steers was 0.55 kg. while that of the non-implanted was only 0.49 kg. The implanted Casanare steers gained 0.48 kg. per day while the non-implanted steers gained only 0.38 kg. per day. On an average, the hormone-treated steers yielded a net return of 13.81 pesos over the non-implanted steers.

It should be pointed out that vaccination for foot-and-mouth disease always produced a loss in weight, not only at La Libertad but also at Palmira and Montería. In some cases, a 45-kg. weight loss was observed which, of course, makes it difficult to evaluate these data and emphasizes the loss that occurs in Colombia due to the vaccination control program for foot-and-mouth disease. Severe weight losses also occur during dipping for control of external parasites. Thus, it is difficult to compare these data with results from the United States.

Crossbred Santa Gertrudis—Sanmartinero steers do well in the Llanos of Colombia.



Weighing an Aberdeen Angus bull at Tibaitatá.

ANIMAL BREEDING

TIBAITATA

Since only 40 head of Angus are available, results obtained from any type of experimentation at this station are of limited value. However, since 1957 three experiments have been conducted in breeding and selection of the Angus herd.

The basis of any selection program must be the individual record of an animal plus the record of performance of its offspring. In these experiments, emphasis is placed upon birth weight, weaning weight, accumulative average daily gain until weaning, and the performance testing data which, in these experiments, are based upon weight and average daily gain from weaning until 18 months of age. These data are summarized in Table 1.

MONTERIA—TURIPANA

At this station, four experiments are in progress in animal breeding. The principal experiment concerns breeding and selection of Romosinuano cattle. All of the females over 24 months of age are in groups of 30 cows formed at random. Each group is in a separate pasture, with one bull, under pasture breeding conditions. When a bull has sired 30 calves or has 30 cows pregnant, he is retired from service until data from his offspring have been analyzed at weaning and at 18 months of age.

These breeding groups also serve as the basis for three other experiments: bull proving and performance testing of offspring, cow proving and performance testing of offspring, and the effect of age at first calving upon final body size and lifetime production. This last experiment is being conducted with three breeding groups: a bull of 24 months of age with heifers 24 months of age, a bull of 24 months of age with heifers 18 months of age, and a bull of 18 months of age with heifers 18 months of age.

Since breeding programs are of long duration, definite results cannot be presented. However, nine bulls now have 30 offspring, but the performance data are not complete.

During 1960, with a total of 443 adult cows, 388 births, and 336 calves weaned, a calving percentage of 87.5, a weaning percentage of

TABLE 1.

Performance testing data on the Angus cattle, Tibaitatá.

	BIRTH		WEANING		Av. daily gain to weaning (kg.)	18 MONTHS		Av. daily gain, weaning to 18 mos. (kg.)
	No. animals	Av. wt. (kg.)	No. animals	Av. wt. (kg.)		No. animals	Av. wt. (kg.)	
Females	16	22.37	12	208.56	0.678	9	332.89	0.449
Males	22	22.22	13	226.92	0.762	5	371.20	0.625
Both sexes	38	22.28	25	218.24	0.694	14	339.86	0.519

TABLE 2.

Performance testing data on the Romosinuano cattle, Montería.

	BIRTH		WEANING		
	No. animals	Av. wt. (kg.)	No. animals	Av. wt. (kg.)	Av. daily gain to weaning (kg.)
Females	220	29.4	170	182.8	0.56
Males	168	30.4	166	201.0	0.63
Both sexes	388	29.8	336	191.8	0.59

75.8 based on number of adult cows, and a mortality of 13.4 up to weaning were obtained.

In Table 2 the available data on performance testing are summarized. Average body weights and average daily gains until weaning are slightly inferior to the Angus of Tibaitatá.

LA LIBERTAD

The breeding and selection work with the Sanmartinero is being conducted with 180 adult females, divided into five breeding groups of single sire matings under a pasture breeding program. The females are placed in breeding groups at 24 months of age. This work is just being organized because of a change in farms and the loss of records from the old station.

The bull and cow proving experiments along with performance of offspring are being conducted, as at other farms, but data are still to be completed for the various age groups.

A crossbreeding program between a small group of 20 Romosinuano females and an Angus bull has recently been started. The first group of calves has not yet been dropped.

ARMERO

At this farm three experiments are in progress with cattle of the Cebú breed, and are being repeated with the Romosinuano herd. The basic experiment, as at the other stations, is that of breeding and selection. The same endpoints are measured for each breed as at the other farms. Selection is based upon the performance of an animal and the performance of its offspring.

In addition to data collected in the breeding and selection experiment, bull and cow proving programs are in progress and performance data of offspring are being recorded. Data are insufficient to present in this report because of the limited number of animals and the fact that these experiments were started only recently.

Animal Physiology

TIBAITATA

A study of growth and adaptation physiology in the Angus and Holstein breeds has been started in the Bogotá area. Thyroid activity has been determined by measurement of blood cholesterol and protein-bound-iodine, and blood volume by the Evans Blue method. It appears that even though hemoglobin, red cell numbers, and blood volume all fall within the normal range for the bovine, all values consistently fall within the upper range of normal. This is especially true for blood volume. There is a marked breed difference in certain of the blood components.

MONTERIA—TURIPANA

As part of the experiment of steer fattening on pasture, female hormones were used to stimulate growth rate. As stated earlier, half the 120 steers in the Montería experiment, 20 of each of the three breeds, were implanted with a commercial product containing progesterone and estradiol benzoate. These hormones in steers produce an increase in average daily gain due possibly to an increase in appetite and to an increased assimilation of nutrients by the organism.

The 60 implanted steers had an initial body weight of 344.1 kg. and a final body weight of 461.7, an increase of 117.6 kg. per head in 168 days, compared with an increase of 86.0 kg. in the non-implanted steers. The on-foot value of these steers was 2.20 pesos per kg. or a total of 69.52 pesos per head. The cost of the hormone was 16.00 pesos per animal, giving a net profit of 53.52 pesos per head of the treated steers.

New milking parlor, Tibaitatá.

Dairy Science

In very general terms, dairying is practiced according to two systems in Colombia, a fact which is true in most tropical countries in this hemisphere. In the favorable climates and on fertile, and usually expensive, lands, the practices are intensified or semi-intensified. These are the areas where climate is moderated by air currents, proximity to large bodies of water, altitude, or latitude. In Colombia, altitude is the most important factor affecting climate. In these favorable climates the more productive breeds are adapted and most of the problems such as forage production, disease control, and general management problems, while somewhat different than in the temperate zones, will yield to the conventional approach followed in the temperate climates. In other words, where production is low in the more favorable areas it can be improved by selection of more productive animals, pasture improvement, and better management.

However, in the zones where environment is unfavorable because of high temperatures, parasites, insects, coarse and fibrous roughages, and perhaps other factors such as length of day, the problems are more complex. Dairying has not progressed very much during many years, and the outlook is not bright, at least when production per cow is compared with that of the European breeds in more favorable climates. In these areas pure European breeds are seldom used; one finds mixtures of European, Indian, and native are common. Undoubtedly much can be done to modify the environment so that the more productive breeds can perform better in such climates. Today, however, the average production per cow in the hot zones is low and dairying is practiced on an extensive basis apparently because the animals are not sufficiently productive to pay for intensified practices in which greater investments in buildings, farm machinery, and labor are needed.

The Colombian dairy program covers these two extremes of conditions. The Tibaitatá and Obonuco stations are representative of the favorable climates, while the farms on the northern coast at Toluviejo and Cereté (Turipaná) are representative of the unfavorable. The farm at Palmira in the Cauca Valley is in an intermediate zone. The climate is not extremely hot but most of the forages are of the coarse type. In addition, the section is operating a farm at El Nus in the Department of Antioquia. The environment here might be considered similar to the Cauca Valley, although it is somewhat more unfavorable because of slightly higher average temperatures, hilly, unplowable land, less fertile soil, and a greater insect and parasite problem—the *Dermatobia hominis* being highly infective in the area. This area is typical of the coffee zones of Colombia.

At Tibaitatá, Palmira, and Obonuco the experimental cattle are Holstein while on the northern coast at Toluviejo and Cereté the only breed at present under study is the native Costeño con Cuernos (CCC). At El Nus another native breed, the Blanco Orejinegro (BON), is being studied.

PERFORMANCE OF HOLSTEIN HERDS

The performance of station herds can serve as a means of evaluating general management practices, as a good indication of the genetic material available, and to bring into focus problems characteristic of the area where the herd is located. Also, the practical experience from operating a herd is of considerable value to young technicians.

PRODUCTION

A summary of the production of the three Holstein herds is given in Table 1.

Any animal in the herd which had freshened, contributed to the total number of cow day regardless of her condition. From these data it appears that there is something radically wrong at Palmira, where only 51% of the total cow days were productive. This is reflected in the calculated average days in milk per cow during the year. Although this might have been due to short lactations, as will be shown later it is actually the result of low fertility and long intervals between calvings. At Tibaitatá an average of 73% of the cows were in milk, which is a little low but not excessively so.

The herd at Tibaitatá continues to show the highest production. The average of 16.5 kg. (36.3 lbs.) milk per day per cow in production is a good level of production and demonstrates the possibilities for the region. The genetic material of the Obonuco herd is not as good as at the other two farms.

BREEDING EFFICIENCY

Breeding efficiency in the three Holstein herds is low, as shown in Table 2. At Palmira, especially, the low fertility is serious. None of the efficiencies based on the results of first services is good, although since these data are based upon observed pregnancies and are not 60–90 day non-returns, they can be expected to be lower than the 70% to 72% non-returns found by the larger artificial-breeding organizations in the United States. Furthermore,

TABLE 1.

Summary of herd production at Tibaitatá, Palmira, and Obonuco.

	Tibaitatá	Palmira	Obonuco
Av. cow days	53.1	46.0	31.7
Av. cow days in milk	39.0	26.0	25.7
% days productive	73.3	51.3	81.0
Milk per cow day (kg.)	12.1	6.4	9.0
Milk per cow day in milk (kg.)	16.5	12.2	11.1
Calculated av. days in milk per cow during year	267.0	177.0	296.0
Av. milk production per cow during year (kg.)	4,406	2,159	3,282

TABLE 2.

Percentage of conceptions resulting from first services and over-all services per conception for the 12-month period ending October 31, 1960.

	Cows having calved at least once			Heifers not having calved		
	Tibaitatá	Palmira	Obonuco	Tibaitatá	Palmira	Obonuco
No. first services	57	46	33	21	9	22
No. conceptions	21	9	15	13	3	10
% conceptions	36.8	19.5	45.5	61.9	33.3	54.5
Total no. services	120	107	52	40	16	39
Total no. conceptions	38	28	22	18	4	11
Services per conception	3.1	3.8	2.36	2.2	4.0	3.9

the number of animals is small. The fact that inseminators do not gain experience rapidly because of the relatively small number of animals bred in a year may also be important.

Another measure of breeding efficiency of the herd is the interval between calvings (Table 3). While over relatively short periods services per conception or breeding efficiency based on first services is probably a better index of fertility, the average interval is an important measurement since long intervals indicate extended dry periods when the cow is not producing milk. This certainly is the case at Palmira, where average cow days in milk and number of services per conception are high. It is generally accepted that 425 days is a sufficiently long interval.

NATIVE BREEDS

Two of the native breeds, the Blanco Orejinegro (BON) and the Costeño con Cuernos (CCC) are being selected for milk production because of their good adaptation to unfavorable climates. The history of these cattle is not well known but probably their ancestors were brought from the Iberian Peninsula to the New World by the early Spanish explorers in order to provide meat and milk for the garrisons and later for the settlers.

The BON apparently are found only in Colombia and are common in the coffee zones, where the land is hilly and temperatures fairly hot. Some people believe that they are descendants of the White Park cattle. The CCC cattle are found in Central America and Venezuela as well as in Colombia. They are usually called "Criollo" and are the breed under study at the Inter-American Institute of Agricultural Sciences, in Turrialba, Costa Rica. In Colombia this breed no longer exists in large numbers and is rapidly disappearing because of crossing, mainly with Indian cattle, the principal type used for meat production in Colombia in the zones where the CCC were most numerous. However, one can still see numerous crossbred animals that have many of the characteristics of the CCC; these are found mainly on the northern coast and in the lower Magdalena Valley.

The work with the BON cattle is conducted at El Nus in Antioquia. The CCC are

TABLE 3.

Intervals between calvings for Holstein cows that calved during 1960.

Station	No. calvings	Av. interval (days)
Tibaitatá	34	442.7
Palmira	16	513
Obonuco	19	419

presently located at the Toluviejo and Turipaná stations on the northern coast. It is planned to move all of the CCC for experimental studies to Turipaná in the near future.

These two breeds are low milk producers, have a marked tendency toward short lactations, and frequently do not let down their milk without prior stimulation by the calf. However, they have received little attention until the last few years and very few data exist as to their response when selected intensively for milk production. These cattle live well in some environments where results with the European breeds have been disappointing. Possibly these native breeds can make an important contribution through selection for milk production or through crossing with the higher-producing but less resistant breeds.

PRODUCTION OF BLANCO OREJINEGRO

The herd of BON at El Nus has been operated for several years. Considerable biometric data have been collected and some selection carried out. Records of parentage are accurate. However, the cows had been milked with calf until two years ago and milk records were not complete for duration of lactation and number of milkings per day. Also, during what might be called the preliminary years of operation, some Jersey bulls had been used. What remains in the way of Jersey blood is in one-quarter blood Jersey animals, the rest having been culled. Today this percentage of Jersey blood is maintained by using one-quarter Jersey—three-quarter BON bulls. The rest of the herd is pure BON. While the production data available are still rather limited, some trends are becoming apparent.

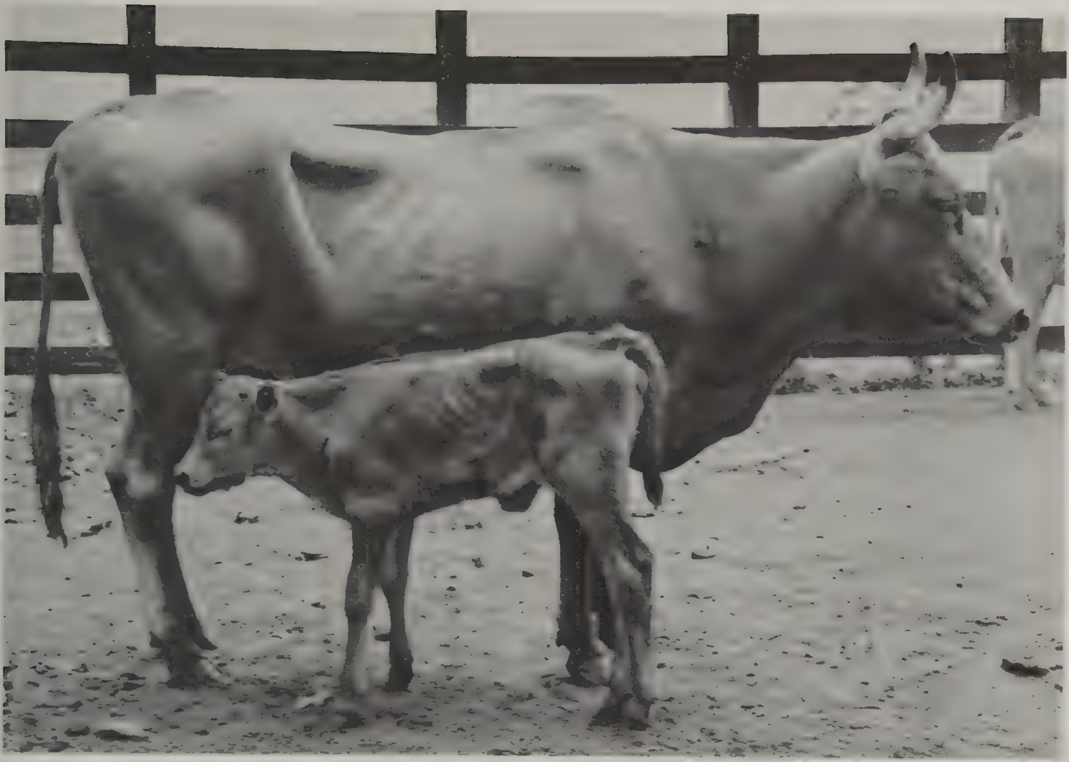
The one-quarter Jersey cows appear to be superior to the pure BON, although the data have not been corrected for age or number of lactations. Number of lactations seems to be important in comparing results with those of other breeds, and especially in animals milked without using the calf to stimulate milk let-down. As the cows become accustomed to being milked without calf, milk let-down usually improves.

The one-quarter Jerseys had lactations twice as long as those of the pure BON, and produced three times as much milk. Furthermore, only about 25% of the Jersey lactations were less than 30 days in length while 50% of the BON had lactations of less than 30 days. This indicates that milk let-down without stimulation by the calf was much better in the one-quarter Jersey cows.

Thus there seems to be a marked favorable effect of relatively small percentages of Jersey blood. By the usual standards the production is very low but it does indicate a possibility of improvement by crossing with European types. No differences in adaptability have been observed between the pure BON and the one-quarter Jersey. At one time there were half-breed Jersey cows on the farm. Reports are that they were not so well adapted as the one-quarter Jersey or the pure BON and for that reason were eliminated. However, there are no reliable production data and these were not well evaluated. Because of the apparent improvement with one-quarter Jersey other studies are being planned using other European breeds for crossing with BON.

PRODUCTION OF COSTEÑO CON CUERNOS

The CCC cattle had been managed very extensively for several years on the farm at Toluviejo. During this period a few of the animals were milked with calf in the field once a day. These data are not considered as a reliable index of their productive capacity. The operation consisted mainly in maintaining this disappearing breed. In the latter part of 1959 a new barn was finished and milking of heifers twice a day without calf was initiated. Since frequently the first calf heifers did not produce enough milk to feed the calf satisfactorily, some of the better older cows were continued in milk with calf but were milked twice a day. The main object of the selection studies is higher milk production and better milk let-down without calf. Although the group being milked with calf will not con-



A typical Costeño con Cuernos cow and calf.

tribute much to the selection program, it fortunately serves as a basis for an evaluation of the milk let-down problem even though these cows are not comparable in age and number of lactations to those in milk without calf.

As with the BON, the production is very low. However, this was the first year of production testing and since the poorest animals finished their lactations in a shorter period than the better ones, a summary of the finished lactations for the year contains a high proportion of cows with low records. In addition, it was necessary not only to accustom heifers to the stable but also to train milkers.

Dairy Calves

Several systems of calf raising are practiced in Colombia but nearly always relatively large quantities of milk are fed. A part of this milk might be sold as human food if other methods for raising calves were used.

The studies which have been conducted are directed toward reducing the amount of milk needed to raise calves. Systems which require from 138 to 212 kg. of milk fed over a period of seven to eight weeks have resulted in satisfactory gains. These systems have been patterned after those used in the United States and other countries in which, during the period of milk feeding, the calves learn to consume a dry starter ration in amounts sufficient to sustain growth when they are weaned.

The dry starter rations used have been mixed from locally grown ingredients and consist mainly of corn, oats, wheat bran, sesame oil meal, barley, and alfalfa meal. Not only does the use of 200 kg. of milk per calf represent a saving of from 400 to 600 kg. for each calf raised, which could be used for increasing the supply for human food, it also results in a saving of about 50% of the cost of raising the calf during the first four months where there is a good milk market.

In most areas of Colombia, forage is not easily cured as hay. In the majority of studies, therefore, fresh or slightly wilted forage has been used for feeding the calves. A trial is presently in progress in which the effect of dried forage or hay is being compared with that of fresh forage. Perhaps calves can consume more energy from the dry, more concentrated hay than from the high moisture forage. In addition to growth measurements, development of rumen activity is being studied by observing calves of different ages during 24-hour periods and noting the time spent ruminating, eating, and drinking.

Since it is desired to select the criollo breeds for milk production without using the calf to stimulate milk let-down, it is important that the criollo calves be raised satisfactorily when they are separated from their dams. In the report last year, it was noted that a system had been devised for the BON calves. This year preliminary work was conducted on raising CCC calves by bucket-feeding. These calves were fed a maximum of 3 kg. of milk daily for two months. The calves had learned to eat satisfactory quantities of a commercial calf starter by the time they were weaned. In a comparative study, calves raised by their dams weighed considerably less at two months of age than those that were hand fed. The BON calves show the same weight advantage in the hand-fed animals but this difference disappears with increase in age. In fact, at about nine months of age, when calves which ran with their dams are weaned, these are heavier and adapt better to pasture conditions than barn-raised calves. It would appear that the problem of raising the young criollo calf will not be difficult but that the change from stable to pasture is a critical one and will have to be studied further.

LENGTH OF GESTATION

A comparative study of gestation length for Holstein, BON, and the one-quarter Jersey—three-quarter BON breeds has been conducted. The Holsteins in the experimental herds had gestations approximately 279 days in length while the BON and one-quarter Jersey had longer gestations by about 4 days. It is interesting to note that the Colombian Holstein Association is basing its new gestation table on 279 days as compared with the 283 days previously used.

FORAGE AND PASTURE

In October, 1960, a grazing trial was initiated to compare the very common kikuyu grass with a mixture of English ryegrass, orchardgrass, and red and white clover. The results to date, although not conclusive, do demonstrate the possibility of high pasture production in the Savannah of Bogotá. There are three replications of each kind of seeding, which are being grazed with Holstein cows. The preliminary results indicate that the kikuyu grass produces more energy per hectare and has a greater carrying capacity but that the mixture is a better quality feed. It is doubtful that the performance of the kikuyu pastures in these trials is normal for the area. These pastures had been recently established and had not become matted and sod bound as is typical of this grass.

No controlled studies were conducted with silages but experience is being gained with this class of forage. In the period since silage making was initiated at Tibaitatá, several hundred tons have been stored in bunker, vertical, and stack silos. At Obonuco, trench silos have been used. All these have given good results with corn and oats. Undoubtedly the most useful experience during the year was derived from making silage in stacks. The silage has been stacked on the ground and afterward covered with straw and soil or just soil. The results have been favorable and this method should enable a farmer to gain experience with silage without investing in more expensive facilities.

COFFEE MEAL

Since there is a large excess of coffee in Colombia, one of the means proposed for utilizing it is to extract the oil for human consumption and use the residue for livestock feed.

A study of this possible use was conducted in two parts: a palatability trial and a growth trial. In the palatability trial, Holstein heifers were offered up to 3 kg. a day of grain mixtures which contained amounts of the coffee meal varying from 0% to 98%. The animals consumed all of the 0% and 25% mixtures; 96.5% of the mix containing 50% coffee meal; 64.5% of the mix with 75% meal; and only 29.4% of the almost pure coffee meal. Even the group which received the mix with 50% coffee meal did not consume it with relish during the latter part of the study.

In the growth study, grain rations containing 0%, 25%, and 50% of the coffee meal were fed to three groups of Holstein heifers, five heifers to a group, during 70 days. The gains per day per heifer were 0.9, 0.82, and 0.62 kg., respectively, for the 0%, 25%, and 50% coffee meal rations.

This meal is not promising but possibly can be used to good advantage in a country where concentrate feeds are scarce and where supplemental feeds are frequently needed because of shortage of pastures during drought. A laboratory analysis showed that the coffee meal contained 1.76% fat, 27.02% fiber, 5.48% ash, 17.41% protein, and 48.33% nitrogen-free extract.

BLOAT

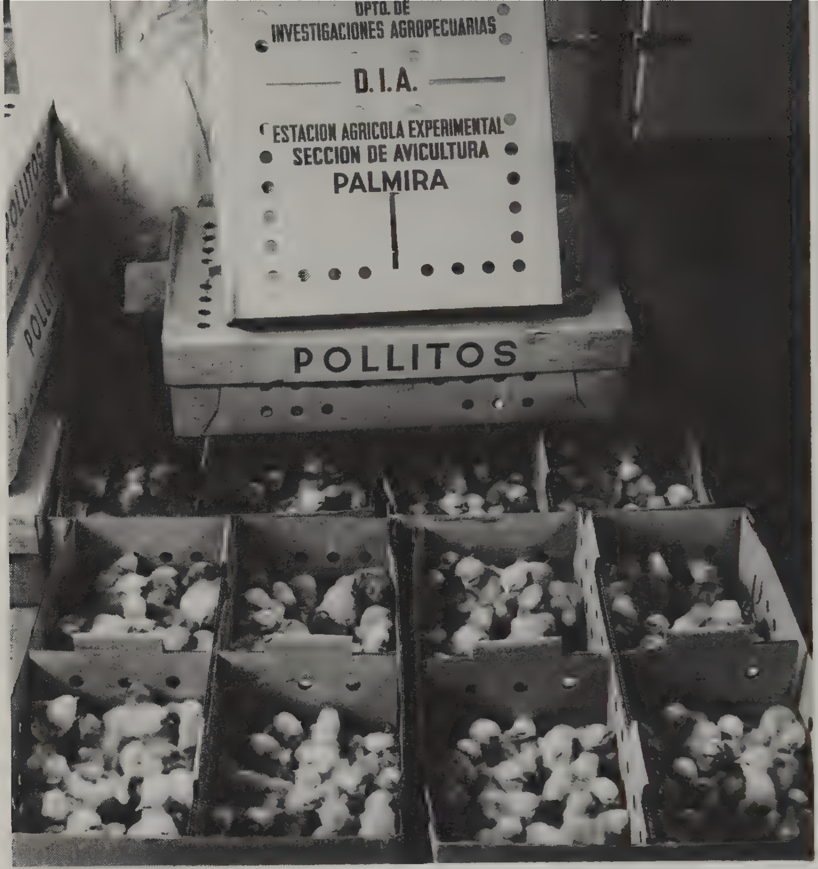
Bloat has been a serious problem at Obonuco. At this station the temperatures and rainfall are such that pastures are succulent during a large part of the year, and the percentage of clover is rather high. Penicillin mixed with the grain ration has been tried as a control. Initial results have been promising, but it is known that other studies have not shown permanent protection with this antibiotic.

Bloat is not generally considered of much consequence in Colombia, probably because there is very little clover in most of the pastures. However, it definitely appears that bloat must be contended with if pastures are improved through the use of clovers.

Another factor which may increase the incidence of bloat in the Obonuco area is the common management practice (for security reasons) of keeping cattle in corrals at night, often with no feed. When the cows return to the pasture, after the morning milking, they are hungry and their intake of forage is rapid. Oat silage fed during the night has not controlled bloat in the station herd.

FROZEN SEMEN

The use of frozen semen imported from the United States was begun during the year. Previously, artificial insemination with refrigerated semen had been practiced in the Holstein herds. Although the number of comparisons is too small for definite conclusions, it seems definite that breeding efficiency is fully as good from frozen semen as from the refrigerated semen. This semen from proven sires should make a substantial contribution toward improving the section's Holstein herds.



Poultry

The poultry industry in Colombia has developed on a commercial basis only in the last few years. Although marked advances have taken place in this time, the supply of poultry products is still much below the demand of national markets.

Ten years ago there were few poultry farms in Colombia and the largest of these had, at the most, only 1,000 birds. Today, the poultry industry is an important source of human food. The growth of the industry has resulted mainly from the increased size of poultry farms in the Departments of Cundinamarca and Valle del Cauca. In the latter there are now breeding farms which raise up to 25,000 chickens.

The poultry population was estimated to be 16 million in 1957, with a value of 80,000,000 pesos. In 1958 the poultry population increased to 18 million, of which 10 million were raised for egg production. Daily egg production was estimated to be 2 million, corresponding to 36,500 tons of eggs yearly, based on 50 grams per egg. Of this amount, approximately 31,025 net tons were consumed in Colombia during the year. Human needs, set at the rate of 15 grams per person per day, would require that a minimum of 74,000 tons of eggs be produced to satisfy the needs of the Colombian population. These figures, for the available supply and the actual needs, show a deficit in egg production for 1958 of 42,975 tons.

There were also approximately 15 million chickens sold for meat purposes in 1958, equivalent to only 1.5 chickens per year for each Colombian. These figures show the great extent to which the poultry industry must be expanded before it can adequately supply the national market.

Data provided by the statistics section of the Comptroller General's office show that the poultry population is now 25 million. Of the total agricultural production in Colombia, 543 million pesos is derived from the poultry industry. Of this, 232 million pesos, or 2.98% of total agricultural production, comes from the sale of poultry, while the remaining 311 million pesos, or 3.99% of total agricultural production, is from the sale of eggs.

With the economy of the poultry industry in its present state, regular consumption of poultry and eggs is limited to those in the upper financial classes. People in lower income groups can afford them only for consumption on holidays. Ideally, meat and eggs should be utilized daily to increase the quality of nutrition and hence productivity. This objective requires an increase in the production of meat and eggs and a reduction in the cost of production. It can be accomplished only by improved poultry management and nutrition, disease control, and better breeds for meat and egg production in Colombia.

The poultry industry is easily adaptable to commercial production on a large scale and, as such, offers a readily available means for farmers to improve their economic level. Production of poultry is also the best means for rapidly increasing the quantity of animal protein available to the Colombian people, since poultry can be raised to marketable age in less time than is required for larger animals.

MANAGEMENT STUDIES

It is important that poultry farmers realize the advantages and disadvantages of different management systems. In 1960 a comparison was made at Tibaitatá of the use of individual and community wire cages for hens raised for egg production. The results for seven months of production show that hens raised in individual cages had slightly greater egg production while consuming somewhat less feed in comparison with those raised in community cages. The greater efficiency of hens in individual cages was undoubtedly due in large part to the greater mortality encountered when hens were kept in community cages. Cannibalism was the major cause of the difference in mortality.

NUTRITION

TIBAITATA

Twelve nutrition experiments were conducted, with a total of 500 chicks per experiment. Each experimental diet was fed to a group of 20 chicks.

In a series of studies, several samples of soybean oil meal manufactured in Colombia were compared with properly heated soybean oil meal obtained from the United States. In several cases soybean meal produced in Colombia was found to be underheated and activity of the anti-trypsin factor was detected which resulted in a marked depression in growth rate of chicks fed these meals. These results show that extreme care must be employed by poultry farmers and feed manufacturers as to the source of soybean meal obtained in Colombia, until such time as soybean processors produce meals that are adequately heated for use in poultry rations. In conjunction with these studies, initial experiments were made on the use of antibiotics, minerals, arsenilic acid, cottonseed meal, and enzymes in poultry rations.

Other studies on the use of dried forages in poultry rations indicated that the type of forage as well as level included in the ration may influence the performance of broiler chicks.

Another study concerned the use of sesame meal in broiler rations. The maximum level of sesame meal tolerated by broiler chicks for rapid growth rate was approximately 20%, an indication that further research is necessary before sesame meal can be recommended as the major protein source in poultry rations.

A study of pullet nutrition was made in conjunction with the experiments on type of management system for laying hens discussed in the previous section. In this experiment a

New Hampshire laying hens in community cages at Tibaitatá.

comparison was made among four commercial diets presently in wide use in Colombia. A total of 600 pullets were fed the diets from four weeks of age through seven months of production. Differences in rate and efficiency of production were very small among hens kept in individual cages except in the case of diet "D," which did not support as high a level of production and efficiency as the other three diets. The comparative value of the different diets fed to hens kept in community cages is uncertain because of the high and quite variable level of mortality encountered.

In a second experiment on pullet nutrition, the substitution of milo for corn and the use of sesame meal and cottonseed meal were studied. In conjunction with this study, the effect of corn, milo, and a synthetic carotenoid (B-apo-8′ carotenal) on egg yolk color was determined. In many cases the synthetic carotenoid produced greater yolk pigmentation than either corn or milo. However, as the increase in yolk pigmentation was not always evident to the same extent, this response could not be depended on.

PALMIRA

In the first nutrition study, the comparative value of four commercial rations for New Hampshire broiler chicks was measured. The large differences in growth rate found among chicks fed these four rations indicate that not all commercial diets produced in Colombia supply nutrients adequate to meet the needs of broiler chicks for rapid growth. A second experiment, in which the four commercial diets were compared with experimental diets and fed to New Hampshire broiler chicks, gave the same results. Studies with laying flocks also indicated that all commercial diets were not nutritionally adequate to support a high rate of egg production.

Other nutrition studies that were initiated include those dealing with the effect of trace minerals and antibiotics in chick diets on rate and efficiency of egg production. No marked differences were observed in percentage production or efficiency of feed utilization, although with the latter measure there may have been a significant improvement in one case due to the inclusion of antibiotics in the diet.

In the picture on page 172 are shown some chicks hatched from the selected breeding stock at Palmira for subsequent use in experimental work.

TULIO OSPINA

A study was made to measure the effect of several different coccidiostats on weight gain, efficiency of feed utilization, and mortality of broiler chicks. Each experimental group contained 137 chicks. In only one case was there any evidence of a depressive effect of a coccidiostat on growth rate; in all other cases, growth rate was similar to that obtained with the control lots. Efficiency of weight gain was similar for all groups. The mortality rate was relatively low in all groups and the differences could not be considered significant. The low mortality in the control lots indicated that the incidence of coccidiosis was very low. This was due to the fact that the experiment was conducted in new pens in an area where poultry had not been raised before, and therefore not exposed to coccidia. It will be necessary to conduct experiments of this nature at a later date where coccidiosis is known to exist in order to prove the effectiveness of these coccidiostats on growth rate, efficiency, and prevention of mortality.

SELECTION AND INCUBATION

TIBAITATA

The program for the improvement of the New Hampshire breed was continued at this station. The purpose of this work is to obtain a line of hens selected for a high rate of egg production. A method of flock selection has been employed whereby only offspring of hens with high records for egg production, fertility, and hatchability are used for subsequent breeding purposes. All hens have been raised in individual wire cages and artificial insemination has been used for the production of fertile eggs.

A total of seven incubations has been made at this station. Part of these were carried out in conjunction with the breeding program. However, other incubation studies have been made to determine the effect of arsenilic acid on fertility and hatchability. Although little effect has been observed on fertility, arsenilic acid appears to improve hatchability and in some cases a sizeable improvement has been noted. These results indicate that arsenilic acid may be at least partially effective in overcoming the poor hatchability which has been observed for hens raised in locations at high altitudes.

Romney Marsh ewe with twins.

Sheep

According to *Economía Colombiana*, published in October, 1957, the average meat production in Colombia during the economically stable years 1951 to 1953 was 383,500 tons. Mutton and lamb comprised only 1,600 tons of the total, most of which was produced and consumed in the two Departments of Boyacá and Santander. The total value of agricultural foodstuffs was reported to be 3,206,900,000 pesos, of which 243,300,000 pesos was the value applied to meats. Only 60,000 pesos of the total value of meat was said to come from sheep. The average per capita meat consumption was around 24.37 kg. per annum, with an average daily per capita consumption of 66.8 grams. Sheep provided only 0.027 grams of the average daily meat consumption.

From a sheep population of around 1,000,000 head, an average of 1.0 kg. per head of wool clip is obtained, giving an approximate total wool production of 1,000 tons annually. The wool produced is of low quality and meets the needs only of the home-type or small industry production of rugs, carpets, and similar materials. In 1959, the country imported 3,400 tons of fine wool for the textile industry. This represented a total cost of 60,959,277 pesos in wool importations.

An average value per head of 45 pesos has been placed on sheep in Colombia. This means a total animal investment of 45,000,000 pesos. According to existing data, Colombia could easily support, in the many regions available to sheep production, 3 million head of sheep which should produce an average of 2.0 kg. of wool per animal, and a similar 100% increase in mutton and lamb production.

ANIMAL MANAGEMENT

In an experiment at San Jorge to study the effect of interval of shearing on wool production, three groups of 25 ewe lambs were randomly formed. One group was sheared every 6 months, one every 9 months, and one every 12 months. Management of all animals was the same. This experiment will continue for a total of 36 months.

According to present results, shearing every 12 months is the most economical, although total wool production is slightly higher with shearing every 6 months.

ANIMAL NUTRITION

Only flock management studies have been conducted in this field. A wether lamb fattening experiment is planned for August, 1961, after weaning of the present lamb crop.

ANIMAL BREEDING AND SELECTION

SAN JORGE

A basic experiment of breeding and selection of the crossbred Romney Marsh breed has been in progress for several years. This experiment is used not only for flock selection but also for ram proving and performance testing of offspring. Body measurements, body weights at determined ages for performance testing, and wool production data are recorded. Breeding efficiency and lambing data are also included in this study.

Similar studies were recently initiated with small flocks of Rambouillet, Corriedale, and Purebred Romney Marsh. Adaptation observations under these climatic conditions are also being recorded. Data are insufficient to present in this report, but it appears that the fine wool breeds may not adapt to this mountainous, high-rainfall region.

Data on body measurements and body weights of the crossbred Romney Marsh males and females at several ages indicate that the greatest increment in body weight and also in height of withers occurs in the period from birth to 90 days of age. Most of these lambs were weaned at 90 days of age, when the females averaged 22.28 and the males 23.35 kg. There is a reduced growth rate from 90 to 180 days of age, due in part to a slowing down of the growth processes, and also in part to a reduced level of nutrition.

Data on wool production in crossbred Romney Marsh females during 1960, according to number of lifetime shearings, show that heaviest wool clip and longest staple length were obtained from the third shearing. From a comparison of these 1960 data with data obtained during several years, it is apparent that usually the third lifetime shearing results in

Corrals at San Jorge.

Romney Marsh crossbred ewes at San Jorge, for breeding and selection studies.

the heaviest wool clip, but that the differences between the second to the sixth shearings are small. Average wool production per animal has been relatively constant during the period 1955–1960.

Males have always produced a heavier wool clip than females. In 1960 the average wool production for males was 4.35 kg. while females produced an average of 3.31 kg. per head.

The lambing percentage has increased gradually during the same five years, and in 1959 91.21% lambing was obtained. This is the highest percentage reported in Colombia. In other countries and with other breeds, lambing percentages of over 130% have been reported. During this same five-year period, mortality has been fairly constant. It is of interest that in these five years only 24 sets of twins and only one set of triplets have been lambed. This may be attributable to breed, nutrition, or a lowered fertility due to high altitude conditions.

Data on ram proving and performance testing are insufficient to present in this report. Growth rates must be obtained at various ages to complete the preliminary data of this study.

TIBAITATA

Similar breeding and selection experiments are in progress at this station with crossbred Romney Marsh animals. These data, and also those for ram proving, are insufficient to present in this report.

During the year, small flocks of Rambouillet, Corriedale, Purebred Romney Marsh, Hampshire, and Suffolk were imported from the United States for this station. These animals are being maintained, and will be entered in similar breeding, selection, and adaptation studies in August, 1961.

Animal Physiology

SAN JORGE

Breeding behavior of the sheep in Colombia is somewhat different from that in other parts of the world. Certain levels of fertility are maintained throughout the year. It is not known whether fertility levels are different in the male and female during the several seasons. However, in a practical experiment to determine whether females are fertile during lactation and to determine the optimum season for breeding, groups of females were placed with males on a year-round basis. During the first semester of this experiment, only one female settled during lactation, and during the second semester two females became pregnant; thus, a total of three females out of 24 were fertile during lactation. Of ewes that lambed, the greatest percentage conceived during the month of April. This is in contrast to the results obtained with larger numbers of animals, when it was found that fertility levels were higher during the fall months.

In another study to determine the periods of greatest weight change during the reproductive life of adult ewes, an increase of 3.50 kg. in body weight was observed in 62 females during the breeding season. A weight loss of 9.29 kg. was reported during lactation, with an average increase of 8.63 kg. between weaning of lambs and entering in breeding.

TIBAITATA

A replication of the San Jorge experiment determining fertility levels during lactation is in progress. A total of three breeding groups, or 75 females, are in this experiment. Data are insufficient to present in this report.

Hampshire and Duroc pigs used in nutrition trials, Tibaitatá.

Swine

Swine production constitutes an important part of the national economy of Colombia. A total of 859,660 head of swine were slaughtered during 1959. This represents 64,474,500 kg. of pork consumed annually. Although data are lacking on the total swine population, it can be stated that both total population and quality of animals produced are greatly below desired numbers and standards.

Until recent years, little emphasis or technical direction had been placed upon the improvement of swine production. Today, however, strong pressure is being placed upon the improvement of swine production systems, and upon the production of a better quality and quantity of pork for local consumption.

Swine Management

TIBAITATA

A pilot experiment to study management and feeding systems of growing-fattening pigs in confinement was conducted at this station. Feed conversion fluctuated between 3.50 and 5.50 and the animals reached a market weight of 100 kg. between the ages of seven and nine months. Little reliance is being placed on these data, since the animals were obtained from many sources and were not a uniform group.

In a second management experiment with a group of crossbred Duroc-Hampshire pigs, an average weaning weight of 20 kg. was obtained at 56 days of age, and market weight of 100 kg. was reached at slightly less than six months of age.

In other pilot management experiments, it was found that weaning weights two to three times the normal in Colombia could be obtained with certain baby-pig diets fed during the first eight weeks after farrowing. When these pigs were placed on growing-fattening diets, some of them reached a market weight of 100 kg. at five months of age.

Swine Nutrition

TIBAITATA

An experiment to study the replacement value of milo for corn with growing-fattening pigs in confinement was recently started. These data will be presented in next year's report. A group of these pigs can be seen in the illustration on page 179. Growth rate during the first part of the experiment has been equal or superior to results obtained in fattening experiments in the United States.

PALMIRA

In the first swine nutrition experiment at Palmira, four commercial diets were compared from the standpoint of feeding value and feed conversion. Eight lots of five pigs per lot were randomly formed. Lots 1 to 4 were Duroc females, and lots 5 to 8 were Duroc barrows. Body weight was taken weekly, and feed consumption daily, during the 91-day experimental period.

A marked difference was observed among the groups fed the different commercial diets. Cumulative average daily gains, in kilograms, during the experiment were 0.55 on diet "A," 0.70 on diet "B," 0.47 on diet "C," and 0.54 on diet "D." The feed conversion rate of the pigs on the different diets was also found to be markedly different, an indication of a wide variation in the quality of the commercial swine rations available to the swine producer in Colombia.

A second experiment, studying the value of milo as a replacement for corn for growing-fattening pigs in confinement, is in progress. This is a replication of the Tibaitatá experiment concerning the effect of climate and altitude on growth rate of fattening pigs.

Breeding and Selection

TIBAITATA

For the first breeding experiment at this station, Duroc and Hampshire swine were purchased locally. Baby-pig mortality was extremely high, especially in the Duroc pigs. This can probably be attributed to certain dietary deficiencies, a complete lack of farrowing and raising facilities, and to a vaccine-break which also contributed to the exaggerated mortality percentage. However, in the surviving pigs, the average weaning weight of 14.91 kg. is a very acceptable figure.

These same animals plus five crossbred Duroc-Hampshire gilts have been placed in another breeding experiment, the results of which will be reported next year.

PALMIRA

In the first breeding experiment here, with 13 Duroc gilts, average litter size was 8.9 pigs, and an average of 8.1 pigs was weaned. Each sow produced an average of 110.2 kg. of pigs per litter. Of the 107 pigs born, only 9 died up to weaning, a mortality of only 8.39%. These data are acceptable under most conditions, and considering the facilities available, the results can be considered excellent.

Animal Pathology

The animal pathology section has made substantial progress during the past year, but this progress is only a small contribution to what must be accomplished in the future. The Colombian government has provided additional professional positions, and the section now has positions filled at all 11 stations having livestock. Additional staff members are being added as the availability of qualified veterinarians permits.

The program of the section has been organized into 10 research projects and administrative areas: general pathology, histopathology, bacteriology and mycology, parasitology, physiology, pharmacology, virology, graduate training, clinics, and administration. The research projects include 60 or more subprojects.

RESEARCH LABORATORIES

The plans for the veterinary research laboratory to be built near the National Veterinary Faculty at Bogotá by DIA are nearing completion.

Also approaching completion are the plans and equipment requirements for the two regional veterinary research laboratories, one situated in the semitropics at Palmira, and the other in the tropics at the Turipaná station, Cereté. Each will be essentially a smaller version of the principal unit at Bogotá. It is planned to build these regional laboratories in three stages: (1) the autopsy and one-half of the laboratory space, (2) the remaining laboratory space, (3) administration, conference, and office areas.

CLINICS

DEVELOPMENT

All 11 stations having livestock now have small clinics with the minimum requirements for maintaining animal health. Additional clinic and stable space has been added as the number of animals has increased at some farms, although further facilities and equipment are necessary at most of them. The situation is particularly crucial at Turipaná, where the livestock has increased fourfold during the past year without any corresponding increase in clinic personnel, facilities, or equipment.

SERVICES

A significant increase in the number of services performed by the clinicians brought the total during the past year to 78,922, or 20

TABLE 1.

Clinic services, 1960.

Services	No.
Control of external parasites (baths, dips, sprays)	9,595
Control of internal parasites (drenches, purgations)	4,139
Laboratory examinations[a]	6,453
Surgery	1,151
Vaccinations, mammals[b]	18,396
Vaccinations, poultry[c]	35,600
Disease diagnoses, mammals	3,299
Disease diagnoses, poultry	289
Total	78,922

[a] Immunological tests (brucellosis, tuberculosis, pullorum, etc.), blood, fecal, urine, and bacterial examinations, animal inoculations, histopathologic slides, miscellaneous examinations.

[b] Anthrax, equine encephalitis, foot-and-mouth disease, hog cholera, ovine ecthyma—strain 19, equine adenitis, blackleg, malignant edema, hemorrhagic -septicemia, vesicular exanthema coital, various bacterins.

[c] Fowl cholera, paratyphoid, Newcastle disease, infectious bronchitis.

services per veterinarian day on a 365-day basis (Table 1). These services include routine preventive measures, diagnoses, treatments, and laboratory examinations. Although actual service represents the major portion of the increase, a part may be credited to a greater appreciation and acceptance of surveillance and record-keeping, an important aspect of the medical sciences. It should be noted that at some stations control of external parasites is performed by the animal management sections, a practice that is recommended. The figure of 9,595 treatments for control of external parasites is thus far from complete.

DIAGNOSIS AND DISEASE OCCURRENCE

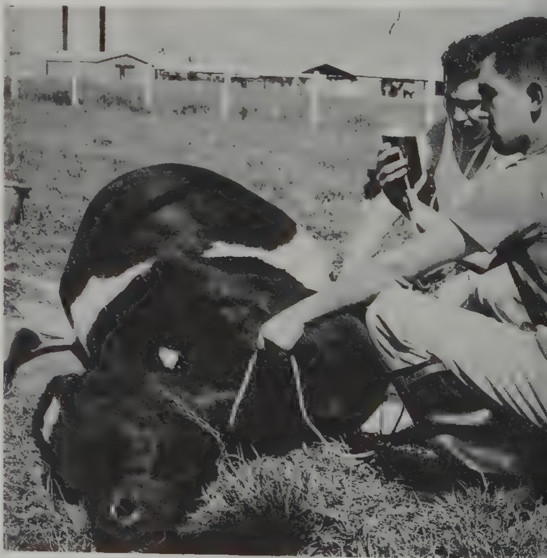
During 1960, 3,299 diagnoses were made of mammalian diseases and conditions, and 289 of avian diseases and conditions. Several items should be commented upon.

Bloat

The majority of the bloat cases occurred in the small Holstein herd at Obonuco. The high incidence of the disease at this station is a severe and continuing problem which is difficult to explain. The altitude, breed, and climate are similar to those at Tibaitatá, where bloat is observed only occasionally. The pasture at Obonuco does, however, include more clover. It is possible that minor differences in management, the pasture composition, and soil differences contribute to the high incidence. Studies have been initiated on the causes of bloat in this area.

Calf Scours and Enteritis

Cases of these conditions, tabulated as coccidiosis, enteroparasites, bacterial, nonspecific, and nutritional enteritis, totaled 892. The greater proportion occurred in the coastal area—Montería, Turipaná, and Toluviejo—where the warm, frequently humid conditions plus poor stabling contribute to the high incidence. Some farms in this area report a 50% loss of the calf crop each year. A major study is being initiated but is handicapped by the lack of facilities outlined above.



Injecting a calcium-dextrose solution intravenously into a cow suffering from "milk fever" at Tibaitatá.

Foot-and-Mouth Disease

It is suspected that inadequate transportation and refrigeration, and high temperatures in the Montería-Turipaná area damaged several lots of foot-and-mouth vaccine. As a result of the incomplete protection of the cattle, 255 so-called "vaccine-breaks" occurred. The fact that such breaks are distressingly common in the area, even when extra precautions are taken, indicates the possible occurrence of subtypes of the virus, against which the vaccine is not effective. Studies are being initiated on the nature of the vaccine-breaks.

Lungworm Infestation

The nematode *Dictyocaulus viviparis* (Bloch) is a severe and widespread problem in Colombian cattle and sheep, particularly in humid or poorly drained areas, where it is compounded by poor management and nutrition. Since there is no effective drug therapy at present, attempts are being made to demonstrate control measures by means of improved management and nutrition. Control of this parasite by the use of drugs is being investigated.

Research

BRUCELLOSIS

Eight Holstein herds in the Savannah of Bogotá, totaling 554 milking animals, were tested for brucellosis (undulant fever in man) by the serum plate and milk ring test. Of the animals tested, 26.98% were reactors, and 32.85% of the pooled milk samples were positive. A high percentage of the milk samples purchased in local stores were positive. Only two of the eight herds had a history of calfhood or adult vaccination. Since the serum titers were frequently very high, the organism was isolated from inoculated guinea pigs and bacterial cultures. Since six of the herds had no history of vaccination, it was concluded that widespread infection exists and that the reactor animals were not the result of indiscriminate adult vaccination, as is frequently assumed locally. The infection represents a great loss to the dairyman annually and is a severe danger to the health of the consuming public. Of 1,000 human blood samples tested from a cross section of the population, five were reactors. This percentage (0.5%) was lower than anticipated; the consumers are either purchasing pasteurized milk or continuing the practice of boiling their milk prior to use. These observations are being extended into the milk-shed of Cali in the Cauca Valley.

The same cow five minutes after receiving the calcium-dextrose solution.

DERMATOBIA HOMINIS

Studies on the control of infestation of cattle with the larvae of *Dermatobia hominis*, locally called "nuche," have been continued. Field studies have confirmed the work reported last year, which showed that the systemic phosphate insecticides offer control superior to that of older methods and, if used extensively in the endemic areas, would result in great savings of hides, meat, and milk and would also reduce debilitation and secondary infections in the animals.

Studies of the life cycle of *Dermatobia hominis* were initiated in collaboration with the entomology section. An interesting facet of the life cycle is that the adult female catches and lays its eggs on other flying insects in banana-like clutches. When the larvae within these eggs are developed, they leave the vector fly as it alights on cattle or other livestock and penetrate the skin of the animal. Numerous flying insects can serve as vectors, some as small as mosquitoes and others equal to or greater in size than the female *Dermatobia*. Bacteria, fungi, and insects have been isolated that rapidly kill or prey upon the larvae or adults. Studies on the vectors, life cycle, and control are being continued.

NEW LIVESTOCK DISEASES

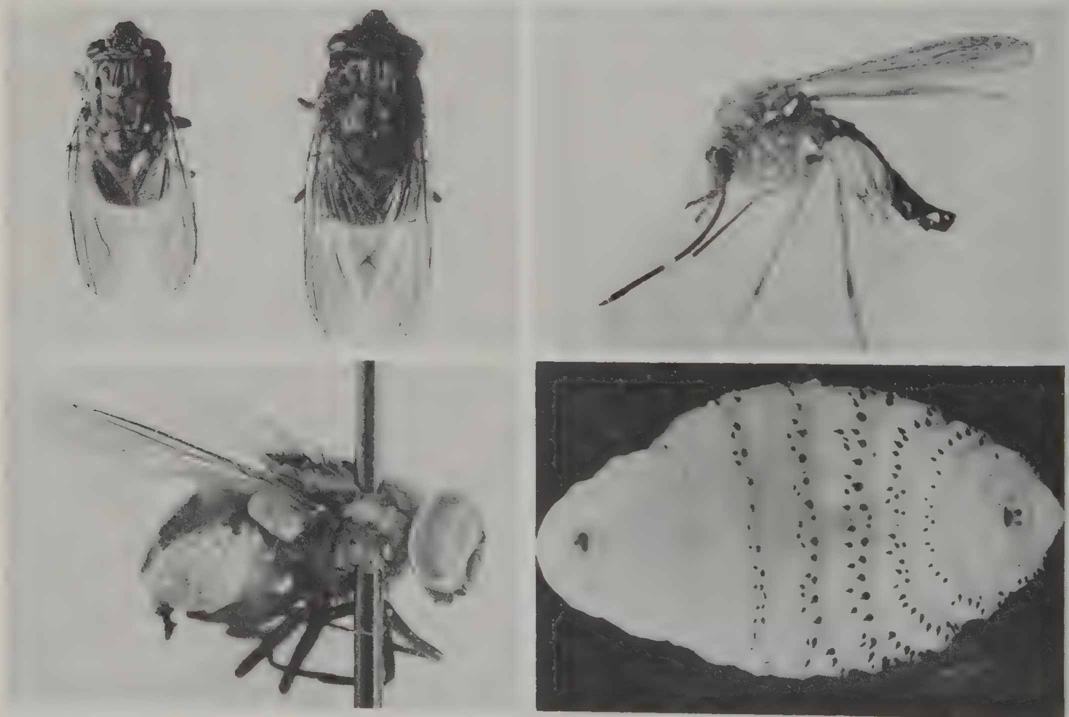
During the past year, three new diseases have been recognized by the section in Colombia: sore mouth, or viral buccal ecthyma of sheep; listerellosis, caused by *Listerella monocytogenes*, which produces a meningo-encephalitis in calves; and infectious bronchitis of poultry.

SWINE ASCARIDS

The field use of the antibiotic hygromycin has proved effective in the prevention of swine ascarids, or round worms, and is now used routinely in young pigs grown by the swine section.

OTHER STUDIES

Work is currently being conducted on epidemiology, surveillance, therapeutics, infectious diseases, and parasitism, including bovine tuberculosis, enteroparasites of sheep and calves, the blood-borne parasites (anaplasmosis and piroplasmosis), and several physiologic problems such as edema, or altitude disease. Clinical evidence suggests that both leptospirosis and vibriosis of cattle are common and widespread in Colombia. It is of the utmost importance that detailed studies of the latter be initiated to confirm the clinical ob-



Upper left: Male and female adult *Dermatobia*. Upper right: Mosquito vector, *Mansonia lynchi*, with small clutch of *Dermatobia* eggs. Lower left: Vector *Orthelia pruna* with a larger clutch of *Dermatobia* eggs. Lower right: Third instar *D. hominis* larva or *nuche*, 3X.

A Blanco Orejinegro steer infested with *nuche* (*Dermatobia hominis*). The same animal, two weeks after treatment, is shown in the picture on page 181.

servations and, if these are correct, to demonstrate diagnostic and control methods to reduce the loss of livestock and to protect public health from these two zoonoses.

PUBLICATIONS

The research papers presented in 1960 are listed in the publications section of this report.

Many of the preliminary results of research by the section were presented at the First Annual Meeting of DIA Veterinarians, attended by over 45 professionals from DIA, the veterinary faculties, and by institutional and private veterinarians. This was the first scientific meeting held for the presentation of veterinary research in Colombia. Seventeen papers, seven demonstrations or movies, three discussion groups, and one seminar were on the program. The response stimulated the demand for a similar meeting annually.

Biometry

The program in biometry is oriented mainly toward servicing the needs of other sections in DIA, chiefly by calculating experimental data. Such analyses are invaluable for critical review of experiments already performed as well as for planning new ones. In 1960 work was initiated with high-speed electronic computers to improve the general computing service. Research within the section was confined largely to methods for determining best sizes of field plots for several crops.

COMPUTING SERVICE

In 1960, 985 experiments were processed by the biometry section. The processing includes calculation of treatment means, analyses of variance, standard errors, and coefficients of variation.

The coefficient of variation is an index of the precision of an experiment. A coefficient of 10%, for example, indicates that the experimental error was one-tenth as large as the mean yield. This level of precision is thoroughly satisfactory for most agricultural work. Coefficients of over 25% indicate, in most instances, an unsatisfactory level of precision. Records of coefficients of variation provide a convenient means for checking the work of the several sections of DIA. One or two poorly controlled experiments, of course, are usually not a cause for concern. A series of ambiguous experiments conducted at low levels of precision, however, properly demands remedial action.

The analyses of experimental data are most useful if they are available shortly after the completion of the experiment. Unfortunately, experimental work is not distributed evenly throughout the year. A great many yield trials are harvested soon after the onset of the intense dry season, which begins in January. It has become increasingly obvious that a prompt computing service would require either more personnel and equipment or more advanced techniques.

In 1960 the Bavaria Brewing and Malting Company installed a high-speed electronic computer in its accounting department. This company, which has collaborated successfully with DIA in research on small grains and corn, generously offered the use of its computer to DIA at no cost for a few hours a week. Provided with data (punched on IBM cards) and instructions, the computer analyzes complicated experiments in a few minutes. Analyses of the same experiments on the most modern desk calculators often require several hours. North Carolina State College generously copied its file of "programs" (instructions) for experimental designs for DIA. These programs include instructions for computing the analyses of all the types of experiments used in DIA. In 1960, personnel of the biometry section were trained in the use of IBM tabulating machines and in the preparation of data cards. On March 3, 1961, the first experiment was successfully processed on the electronic computer.

It appears that the computer will be most useful in analyzing data from yield trials in which large numbers of varieties are compared. Usually the experimental arrangement is standardized, so that several such experiments can be fed into the computer consecutively without adjustments. Small experiments of a special nature are still most conveniently processed on desk calculators.

SPECIAL STUDIES

Size of field plot affects both the precision and cost of experiments. In general, use of large plots tends to average out the small variation in soil in experimental fields and thus contributes to precision. Unfortunately, the area occupied by an experiment increases with increasing size of plot. The problem thus becomes one of striking an efficient balance. Use of too large a plot is wasteful of land, while too small a plot entails loss of precision and leads to ambiguous results.

Fortunately, it is possible to study experimentally the relation between plot size and precision (as measured by the coefficient of variation). The so-called "uniformity trial" is the most direct method for studying this relationship. A field sown to a single variety (for example, a commercial planting of hybrid corn or a new variety) is divided into many small plots, which are harvested individually. Careful record is kept of the geographical location of each plot. In the laboratory, adjacent plots can be combined into artificial plots of larger size. In this fashion, coefficients of variability can be calculated for plots of several sizes. Plotting these results on Cartesian coordinates shows how much precision is gained by the use of larger plots. The rate of gain in precision is a characteristic of the experimental field. If the increase in precision from using large plots is small, then small plots are recommended. Uniformity trials have been conducted in corn, potatoes, and small grains under the direction of personnel of the biometry section.

TRAINING

Since such basic decisions as number of replications or type of experimental arrangement require an understanding of statistical principles, regular classes in experimental statistics were initiated in 1960 for DIA personnel who conduct or work on experimental projects.

Within the biometry section an important objective has been the training of competent professional statisticians. The transfer of the head of the section to new duties with the agricultural program of The Rockefeller Foundation in Mexico means that future work in experimental statistics in DIA will be directed by Colombian statisticians. Fortunately, in 1960, an agronomist of the section initiated studies for an advanced degree at North Carolina State College. There is reason to hope that competent professional leadership in statistics will not be lacking in Colombia in the years to come.

Rotary lime spreader made from old automobile parts.

Farm Administration

The engineering section of Tibaitatá was transferred to Bogotá in September, 1960, to become part of the central planning office. This change will provide an organization which will be able to plan and direct the engineering and development work at the various experiment stations more efficiently.

An active building program was carried on simultaneously at eight experiment stations during 1960. Most of the work was accomplished by non-professional personnel trained at Tibaitatá, using the plans developed in the central planning office. Supervision of this work was accomplished by the two engineers of this section.

The development of the building programs which have been projected for Palmira and Turipaná will require a considerable amount of time of the present personnel in the section. A certain amount of effort is also required for the development of other stations. A work priority system is being established by the planning office, in cooperation with the directors of the experiment stations and DIA staff, which will help to alleviate the present difficulty of working at all stations simultaneously. To expedite station development, additional personnel are needed in the planning and engineering sections, as well as skilled workers for the various construction projects.

Construction and Field Improvement

The following is a list of the projects completed at experiment stations during 1960.

TIBAITATA

(1) New roofing was applied on the main laboratory and administration building, the workers' living quarters, and on the houses of the station director and administrator.

(2) An addition of 250 square meters was made on the storage and supply building to provide adequate facilities for storage.

(3) Floors, soil bins, and work rooms were constructed in the head house to provide work room for the preparation and planting of experiments for the greenhouse.

(4) A rat-proof mezzanine was constructed in the grain storage building for the storage of equipment and supplies used in the corn program.

(5) Power, telephone, water, and sewage lines were installed in the various buildings in the animal industry sections. Approxi-

mately 2,000 square meters of concrete corrals were also constructed in the animal industry section.

(6) Most of the buildings on the station were repainted.

(7) Equipment was installed in various laboratories.

TURIPANA

(1) Additional roads have been surveyed and cleared in preparation for surfacing.

(2) A large field, representative of the uneven terrain in the area, was leveled and a record made of the cuts and fills. This field is being cultivated and planted in cooperation with the soils and forage sections. It will be an experimental area to determine the effect of the movement of soil, with the resultant exposure of the subsoil, on plant development and production. The data obtained in this experiment will be used in establishing the methods to be followed in leveling and preparing the soil in this area for crop production.

(3) An additional 130 acres was leveled and prepared for planting of experimental plots.

(4) The provisional farm shop has been able to maintain the equipment in operation despite the lack of many facilities.

PALMIRA

(1) Additional land was acquired at this station for the animal industry sections. Drainage canals were relocated to allow for a better division of fields and to connect into the main drainage system of the station.

(2) Approximately 2.5 miles of roads have been built but have not been surfaced.

(3) Construction plans for a new farm shop and the beef section have been completed. The development of facilities in the poultry and hog sections is progressing.

NATAIMA

(1) The construction of the director's house has been completed.

(2) A farm storage building of 250 square meters area has been completed and is in operation. The inability to secure structural steel has delayed the construction of two other buildings.

(3) A sedimentation tank, to remove sand from the irrigation water used on the rice experimental fields, has been completed.

LA LIBERTAD

(1) All the construction begun in 1959 at this station has been completed.

(2) A cattle dipping vat for the control of parasites was constructed and placed in operation.

ARMERO

(1) The lack of trained construction workers and the urgency of other projects has delayed the development of this station. The veterinary clinic was completed, however, and land clearing and fence and corral building is progressing.

OBONUCO

(1) Land clearing both by contract and by station personnel is progressing and approximately 100 acres have now been cleared for the planting of crops which could not be planted previously.

(2) The farm shop, which was inadequate, was replaced by a modern, 400-square-meter building for storage of farm supplies and maintenance of farm machinery. A similar

New calf nutrition barn, Tibaitatá.

building for the storage of farm machinery was also completed.

(3) A grain storage and office space for personnel of the small grain program was completed.

(4) The road system in both the crop and dairy sections has been completed.

(5) An area has been leveled for the construction of new dairy buildings which, being more centrally located, will provide greater efficiency in dairy management.

SURBATA

(1) The grain storage, potato storage, and farm shop buildings, totaling 750 square meters in area, have been completed, as well as a 700-square-meter grain drying platform. A small house on the farm was completely modernized and another removed.

(2) The drainage and irrigation system has been completed and is in operation. With the present system the farm can be irrigated at any time either by gravity or by pumping units. The system has a water storage capacity of over 5,000 cubic meters for use in irrigation during the dry season.

(3) Most of the farm has been leveled and is being prepared for planting.

BOGOTA

(1) Considerable time was spent in checking and modifying plans for the veterinary clinic proposed for the National University. This clinic, as now designed, will cost approximately four million pesos. Plans for the building are being contracted and will be reviewed and modified as necessary by the engineering section in cooperation with the section of veterinary medicine.

MACHINERY

Eleven new tractors were purchased during the year and various old machines were rebuilt. At Tibaitatá, a lime spreader was designed and built from discarded automobile parts. The local lime, which is full of stone and often very damp, cannot be spread satisfactorily with standard spreaders. The farm-built rotary spreader operates satisfactorily with the quality of lime available and was constructed at a very low cost.

With approximately 30 miles of roads urgently needed on various farms and road building material available free or at reasonable cost, a 1-yard loader and two 6-ton dump trucks have been purchased to work as a unit with a D-4 bulldozer and four dump trucks from other stations. This unit will greatly increase the efficiency of road construction which is necessary for the operation of the various experiment stations.

Seed Distribution

During the past year, seed was sent from the Colombian Agricultural Program to the following individuals and institutions:

Name	*Institution*	*Location*
H. C. Thorpe	F. A. O.	Manila, Philippines
J. A. Rupert	The Rockefeller Foundation	Santiago, Chile
——	Colombian Embassy	San José, Costa Rica
Hernán Orellana	National Wheat Commission	Quito, Ecuador
——	Ministry of Agriculture	Guatemala
Giles Dixon	Ministry of Agriculture	Njoro, Kenya
Ignacio Narváez	National Institute of Agricultural Research	Mexico, D. F., Mexico
——	I.C.A.	Nepal
Rosendo Postigo	Ministry of Agriculture	Lima, Peru
Rufus Walker	Narfarm, Inc.	Valencia, Venezuela
James Dickson	Ansor Corporation	Philippines
Roscoe Taylor	Alaska Experiment Station	Palmer, Alaska
——	Argentine Brewing Co.	Buenos Aires, Argentina
Robert Romig	The Rockefeller Foundation	Santiago, Chile
——	Ministry of Agriculture	Caracas, Venezuela
H. Beachell	Texas Experiment Station	Beaumont, Texas
N. E. Borlaug	The Rockefeller Foundation	Mexico, D. F., Mexico
——	University of Minnesota, Department of Horticulture	St. Paul, Minnesota
——	Potato Introduction Station	Sturgeon Bay, Wisconsin
——	Department of Agricultural Investigations	Santiago, Chile
Gonzalo Luzuriaga	Central University	Quito, Ecuador
——	Hacienda Monte Sacro	Valencia, Venezuela
Angel Salazar	Central American Corn Improvement Program	Mexico, D. F., Mexico
Eva Potztal	Botanical Garden and Museum	Berlin, Germany
Guillermo Merino	University of Quito	Quito, Ecuador
C. T. Walker	Colonial Pesticides Research Unit	Salisbury, England
Rudolf Schick	Plant Protection Institute	Rostock, Germany

Chilean Agricultural Program

Picture credits:
Dwight Worsham, pp. 193, 210;
Victor Kabath, pp. 199. 218.

Personnel

CHILEAN AGRICULTURAL PROGRAM

MINISTRY OF AGRICULTURE

His Excellency, **Sr. J. Manuel Casanueva Ramírez,** ING. AGR., Minister of Agriculture
Ciro Iturriaga Garcés, Subsecretary of Agriculture
Virgilio Mannarelli M., ING. AGR., Director of Agriculture and Fisheries
Dionisio Pavez Saa, ING. AGR., Coordinator of Agricultural Research
Claudio Vergara Castillo, ING. AGR., Chief, Department of Agricultural Research
René Cortázar Sagarmínaga, M.S., Assistant Chief, Department of Agricultural Research (on leave)
Mario Rogers Moreno, ING. AGR., Secretary General, Department of Agricultural Research
Hiram Grove Valenzuela, PH.D., Director, Central Experiment Station, Santiago
Alejandro Violic Martinovic, ING. AGR., Director, South-Central Experiment Station, Chillán (on leave)
Alfredo Mathieu Kohler, ING. AGR., Director, Southern Experiment Station, Temuco

OFFICE OF SPECIAL STUDIES

Joseph A. Rupert, PH.D., Director, The Rockefeller Foundation
Manuel Sánchez Nelson, ING. AGR., Administrative Assistant

CEREAL IMPROVEMENT

Robert W. Romig, PH.D., Geneticist, The Rockefeller Foundation
René Cortázar Sagarmínaga, M.S., Head, Cereal Improvement (on leave)
Ignacio Ramírez Araya, ING. AGR., Geneticist, Acting Head, Cereal Improvement
Rodolfo González Bueno, M.S., Geneticist, in charge, Santiago Station
Héctor Wulf Márquez, ING. AGR., Head, Farinology Laboratory, Santiago Station

Oscar Moreno Mucke, ING. AGR., Assistant Geneticist, Santiago Station
Patricio Parodi Pinedo, ING. AGR., Assistant Geneticist, Santiago Station
Luis del Villar Zarco, M.S., Geneticist, in charge, Chillán Station (until November, 1960)
Lilian Aguayo Chávez, ING. AGR., Assistant Geneticist, Chillán Station
Juan Acevedo Acevedo, ING. AGR., Assistant Agronomist, in charge, Temuco Station
Sergio Rivas Alonso, ING. AGR., Assistant Agronomist, Temuco Station
Patricio Barriga Bezanilla, Student in Training, Santiago Station
Iván Correa Opazo, Student in Training, Santiago Station
Jaime Hermosilla Catalán, Student in Training, Santiago Station
Marcelo Valdovinos Salas, Student in Training, Chillán Station

FORAGE AND PASTURE PROGRAM

Donald L. McCune, PH.D., Agronomist, The Rockefeller Foundation
Paul J. Fitzgerald, PH.D., Geneticist, The Rockefeller Foundation
Hiram Grove Valenzuela, PH.D., Head, Forage Program
Talía Gutiérrez von Hundt, ING. AGR., Geneticist, Osorno Station
Fernando Ortiz Silva, ING. AGR., Assistant Agronomist, Valdivia Station
Jorge Silva Fuentes, M.S., Geneticist, in charge, Temuco Station
Domingo Cerviño Arévalo, ING. AGR., Assistant Agronomist, Temuco Station
Gustavo Cubillos Oyarzo, ING. AGR., Assistant Agronomist, Temuco Station (on leave)
Sergio Bonilla Espíndola, ING. AGR., Assistant Agronomist, in charge, Chillán Station
Alfredo San Juan Hoyos, ING. AGR., Assistant Geneticist, Chillán Station
Hugo Aguila Castro, ING. AGR., Assistant Agronomist, Chillán Station
Ignacio Ruiz Núñez, ING. AGR., Assistant Agronomist, Chillán Station
José Jaime Vicens Obrador, ING. AGR., Assistant Agronomist, in charge, Dryland Research, Santiago Region (on leave)
Claudio Bariggi Zambra, ING. AGR., Assistant Agronomist, Dryland Research, Santiago Region
Patricio Azócar Cabrera, ING. AGR., Assistant Agronomist, Santiago Station
Raúl Avendaño Troncoso, ING. AGR., Assistant Geneticist, Santiago Station
Eduardo Riveros Veas, ING. AGR., Assistant Agronomist, Santiago Station
Juan Obrador Rousseau, ING. AGR., Assistant Agronomist, Santiago Station
Gonzalo Gil Salaya, ING. AGR., Assistant Geneticist, Santiago Station
Fernando Cosio González, Student in Training, Santiago Station
Juan Domingo Dávila Rodríguez, Student in Training, Santiago Station
Marcos Figueroa Robinson, Student in Training, Chillán Station
Abdón Guíñez Silva, Student in Training, Santiago Station
Osvaldo Luco Echeverría, Student in Training, Santiago Station
Eugenio Maffei Reyes, Student in Training, Santiago Station
Eugenio Munita Valdés, Student in Training, Santiago Station
Mario Núñez Ramírez, Student in Training, Santiago Station
Alicia Vergara Scarbourough, Student in Training, Santiago Station

EXPERIMENT STATION OPERATIONS

Arthur D. Leach, PH.D., Associate Agricultural Engineer, The Rockefeller Foundation

Oscar Lillo Valladares, Architect (temporarily assigned to the Office of Special Studies)

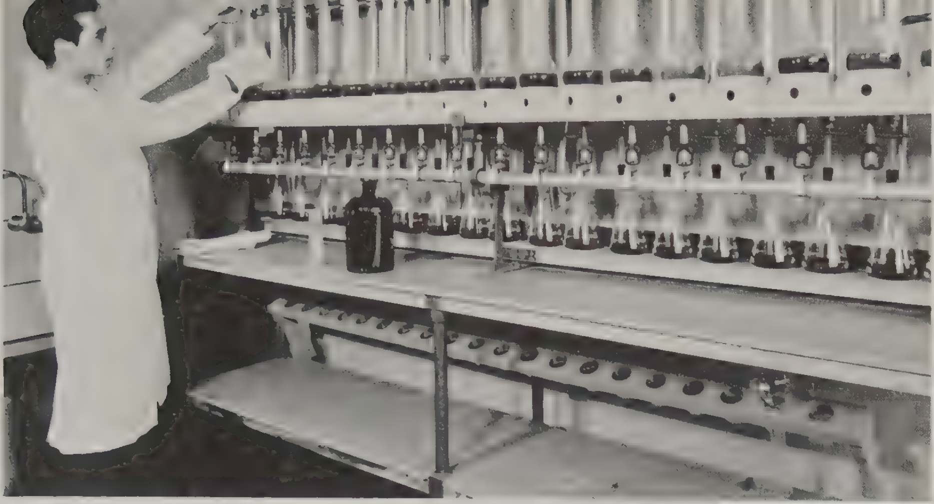
Michael Raczynski Von Oppen, ING. AGR., Assistant Agronomist, Santiago Station

Edgardo Ossandón Prudent, ING. AGR., Assistant Agronomist, Temuco Station

Manuel Gómez Maira, ING. AGR., Assistant Agronomist, Santiago Station

Alfonso Salazar Domeyko, ING. AGR., Assistant Agronomist, Santiago Station

Horacio Urzúa Sotomayor, Student in Training, Santiago Station



Protein analysis in the farinology laboratory.

Director's Introduction

A new Ten Year Plan of Economic Development recently announced by the Government of Chile calls for expansion in production of 55% in food crops and 69% in livestock by 1970. It is essential that most of this increase be obtained through more efficient use of the existing arable lands, since the present possibilities of bringing new areas into production are quite limited. According to the plan wheat production should expand 19%, meat 72%, and milk 95% during the next ten years. In order to achieve the increases in meat and milk production, it is estimated that an additional 650,000 hectares of improved pastures must be established and maintained on land now in natural pastures. On the basis of results obtained to date by the Office of Special Studies and described in this report, it is believed that the goals proposed in the plan are realistic.

Four new wheats that yield better than the improved variety Orofén are now in the first stages of multiplication; three of these will be distributed in the central zone and one in the intermediate zone. Orofén and the improved variety Rulofén have performed well during the past season, and it is estimated that they will be sown on about 50% of the spring wheat area in 1961. With the use of improved varieties and with the present trend toward the use of more chemical fertilizers, the goal set by the ten-year plan can be attained.

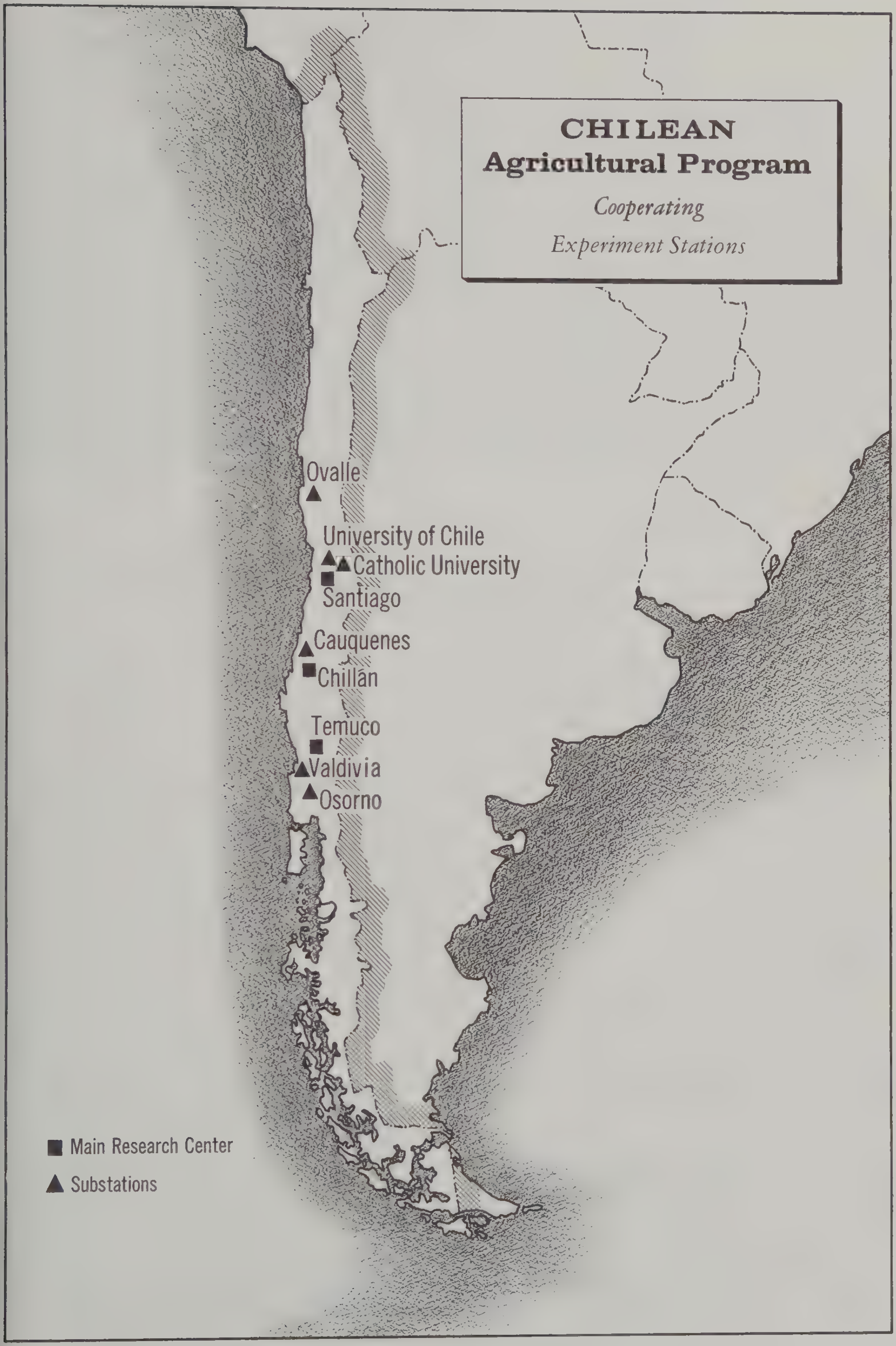
With the appointment of Dr. Paul J. Fitzgerald in October, 1960, to fill the position of Forage Geneticist, greater emphasis is being given to the improvement of varieties through breeding and selection. Special attention will be devoted to developing forage legumes with resistance to nematodes, as a means of controlling serious losses and extending the longevity of stands.

The forage program has developed new strains of alfalfa, red clover, and birdsfoot trefoil, of which foundation seed is being released for further increase. In addition, as a result of extensive testing of introduced material, commercial quantities of Moapa alfalfa, Caladino white clover, and Clare subterranean clover have been imported directly from the countries of origin by both government and private organizations. In a grazing trial on an improved pasture seeded with a mixture of ryegrass and white clover, more than 1,000 kg. of beef per hectare were produced without supplemental feeding in only 126 days. This trial is being conducted in cooperation with the School of Agronomy of the University of Concepción at Chillán.

Better research facilities are becoming available at the two new experiment stations located near Santiago and Temuco as the building program progresses and the experimental fields are cleared, leveled, and integrated into a network of roads and irrigation canals. Mr. James Myler, Director of Field Stations, University of California, visited Chile a second time for two months to lend his broad experience to the planning and development of the stations. His assistance has been of inestimable value.

In anticipation of the need for studies in animal nutrition and forage utilization, plans for the provision of adequate field and laboratory facilities were elaborated by Mr. Norval Curry, formerly of Iowa State College, and Dr. James Fransen, of the Colombian Agricultural Program, with the collaboration of personnel from the local staff of the Office of Special Studies and the Ministry of Agriculture. The projected building schedule is to be executed by stages as trained technical personnel become available.

The strong emphasis given to student training within the program is reflected in the growing number of applications received for one year of practical field research and for part-time participation during the school vacation periods. A total of 29 trainees gained experience in field research and received technical guidance on their theses in the past year.


CHILEAN
Agricultural Program
Cooperating
Experiment Stations
Ovalle
University of Chile
Catholic University
Santiago
Cauquenes
Chillan
Temuco
Valdivia
Osorno
■ Main Research Center
▲ Substations

Chilean Agricultural Program. Cooperating Experiment Stations.

	Location	Size (acres)	Altitude (feet)	Av. temp. (°F.)		Av. rainfall (inches)	Soil types	Principal fields of investigation	Type of agriculture in region served
				Jan.	July				
MINISTRY OF AGRICULTURE STATIONS									
Central Experiment Station	Santiago	753	2,064	69.1	46.4	15.6	Non-calcic Brown; Alluvial	Corn, cereals, beans; Forage crops; Oil crops	Crops; Fruit; Livestock; Dairy (Irrigated)
Substation	Ovalle	250	797	67.6	52.0	5.1	Calcic Brown; Alluvial	Cereals	Dryland farming (Supplementary irrigation)
Substation	Cauquenes	1,500	472	71.8	48.2	28.0	Reddish-brown Laterite	Range management	Dryland farming
Southern Experiment Station	Temuco	555	1,056	62.6	46.0	53.0	Alluvial; Volcanic Ash (Trumao)[a]	Cereals, potatoes; Forage crops; Oil crops; Soil fertility	Crops; Livestock; Dairy (Supplementary irrigation)
Southern Region Substation	Osorno	325	75	63.7	46.7	52.5	Trumao	Cereals; Forage crops	Crops; Livestock; Dairy (Dryland)
MINISTRY OF AGRICULTURE—UNIVERSITY OF CONCEPCION									
South-Central Experiment Station	Chillán	750	374	71.4	48.4	40.5	Trumao with Grumosol inclusions	Corn, cereals; Forage crops; Oil crops; Animal nutrition	Mixed farming (Supplementary irrigation)
UNIVERSITY STATIONS									
University of Chile	Santiago	3,000	1,476	69.1	46.4	14.3	Non-calcic Brown	Corn, cereals, fruit; Forage crops; Dairy science	Mixed farming (Irrigated and dryland)
Catholic University	Santiago	750	2,182	69.1	46.4	19.7	Non-calcic Brown (modified)	Corn, cereals; Forage crops; Poultry; Dairy science	Mixed farming (Irrigated)
University of the South	Valdivia	375	43	62.8	46.0	99.0	Trumao	Potatoes; Forage crops	Crops; Livestock; Dairy (Dryland)

[a] The "Trumao" soils of southern Chile are similar to the Ando soils of Japan, the Yellow-brown Loam of New Zealand, and some of the volcanic formations in Oregon, U.S.A.

Field day in the winter wheat plots, Temuco.

Wheat

The stem-rust resistant wheat variety Orofén, released by the Office of Special Studies in 1958, has been well accepted in the northern wheat zone of Chile. Record yields of more than 6.5 metric tons/ha. together with average yields that exceed those of other varieties by up to 1 ton/ha. have contributed to the popularity of the variety. The Agricultural Bank sold its total supply of 4,000 metric tons of seed in less than a month after it was available for distribution. This amount of seed will sow about 25,000 hectares. It is estimated that about 50% of the northern bread-wheat area (75,000 hectares) will be planted to Orofén during the next season.

Approximately 400 hectares of Rulofén, the second variety released by the Office, were grown during the 1960 season and 300 tons of certified seed were produced. It is expected that about 4,000 hectares of this variety will be grown next season. Yields of up to 5.2 tons/ha. on irrigated land and of up to 2.7 tons/ha. on dryland were recorded this year in the certified seed campaign. Of special interest to the producers were its resistance to lodging and shattering and its early maturity.

When grown in the area north of O'Higgins province, both Orofén and Rulofén ripen early enough to permit the cultivation of row crops during the same season on land that produces wheat. Rulofén is particularly well suited for double-cropping since it matures earlier than any other commercial variety now grown in Chile. A few farmers have taken advantage of the earliness of these two wheats and have reseeded a portion of their land to corn or sunflower after their wheat harvest. Preliminary experiences with this practice indicate that normal or near normal yields can be obtained from the second crop. Double-cropping, such as this, could develop into an established pattern in the northern central valley now that high-yielding, early maturing wheat varieties are available.

New Varieties

Two of four new spring wheat varieties awaiting release should also be especially suited for double-cropping since they are in the same maturity class as Rulofén. In fact, Nortefén (Thatcher-Santa Catalina × Mayo 54) ripens a few days earlier. Both Nortefén and Primafén (Frocor-Fontana/Yaqui × Nariño sib) combine high yield, good quality, and disease resistance with early maturity. Their quality for bread is superior to that of any wheat now cultivated in Chile.

The other two spring wheats awaiting release are both derived from the cross that produced Orofén. No name change is contemplated for one of the selections, since it is phenotypically similar to Orofén. However, this selection has consistently outyielded Orofén and so will be used to replenish seed stocks of this variety. The other selection has been named Chifén and is quite different in appearance. It is somewhat taller and later, and has better resistance to leaf and stripe rust, as well as better quality than Orofén.

Chifén will be recommended for the intermediate and southern wheat zones where it has yielded well from spring plantings. At Chillán, Chifén, seeded late in August, outyielded the standard varieties Cappelle Desprez and Vilmorin 29 sown in May. At Temuco, from mid-August plantings, Chifén yielded more than Vilmorin 29, the variety most commonly used for late plantings in the winter wheat area.

NORTHERN WHEAT ZONE

Investigations for the northern wheat zone are now concentrated at the new Central Experiment Station near Santiago. This station serves the area north of Linares province in which about 150,000 hectares of spring wheat are grown annually under both dryland and irrigated conditions. In addition, almost all of the durum wheat grown in Chile, about 50,000 hectares, is produced in this area.

CULTURAL PRACTICES

Experiments involving rate of fertilizer application, rate and date of seeding, and rate and date of herbicide application, using Orofén as the test variety, have shown that higher yields and lower production costs can be achieved through better management practices.

The opinion is widely held that wheat does not respond to phosphate fertilization in the northern zone. However, a positive response of wheat yields to phosphate was observed in a trial conducted this year. While levels of phosphate application in the northern zone need not be so high as in the south, nevertheless, applications of this essential element are required for maximum yields. The best fertilizer treatment, which was at the rate of 80 kg./ha. of P_2O_5 applied in the row, increased yields by 30%. Surprisingly, no yield response to nitrogen (applied as KNO_3) was observed even with application of up to 256 kg./ha.

A higher yield was obtained from a seeding rate of 150 kg./ha. in a late August seeding of Orofén than from rates of 100 or 50 kg./ha. The 150 kg./ha. rate produced 700 kg./ha. more grain than the rate of 100 kg./ha. and produced an increase in yield of 1,400 kg./ha. over the rate of 50 kg./ha.

A standard seeding rate of 150 kg./ha. was used in a study of the effect of date of seeding. Plantings were made at bi-weekly intervals from March to May and at monthly intervals from June to September. The best yields for spring wheats were obtained from an early June seeding. The best time for seeding the winter wheats was mid-April. Of interest is the fact that winter wheats headed when planted as late as mid-August in the Santiago area.

Large differences in weed control were associated with different concentrations and different dates of application of both DNBP and the isopropyl ester form of 2,4-D. Both products were used in pre- and post-emergence treatments at three concentrations. The best weed control was obtained with 2,4-D applied at the manufacturer's recommended concentrations at the tillering stage of development.

VARIETAL IMPROVEMENT

Introductions of spring wheats from the Colombian and Mexican programs have been the source of the new varieties as well as of many of the better wheats now in yield trials. Consequently, new germ plasm from these countries is evaluated every year. During the report period, about 800 wheat lines were chosen for further testing from among the more than 5,500 experimental varieties received from Colombia and Mexico. In addition, 2,400 plants were harvested from 3,800 F_2 lines derived from crosses made in Colombia and Peru. (Introductions from Argentina, even though they have not yielded well in comparison with other varieties, have shown good quality when grown in Chile.)

The introduction of well-adapted wheats has stimulated the development of a vigorous hybridization program with spring types. The program reached a peak this year with 2,600 crosses to combine disease resistance and quality with other desirable characteristics. It is expected that fewer crosses between spring types will be made in the coming season.

In progress are the development of: a leaf-rust resistant Orofén (using the high-yielding selection as the recurrent parent); a stem-rust resistant Menflo; stem-rust resistant lines of the stiff-strawed, high-yielding Italian varieties Mara, Generoso, Campodoro, and Funo; stem-rust resistant, high-yielding wheats with excellent quality; and rust-resistant dwarf and semi-dwarf forms of Orofén and Menflo.

Stem- and leaf-rust resistant winter wheats with adaptation for the northern wheat zone are also under development. More than 1,300 selections have been made for the next year. Possible benefits from the use of winter wheats in this zone are higher grain yields and supplemental forage for fall and winter grazing. None of the 225 winter varieties in yield trials had an acceptable reaction to stem rust.

Rigorous selection for resistance to stem rust and for good agronomic type has reduced the size of the durum wheat nursery. However, six preliminary multiplication plots of stem-rust resistant durum wheats were planted in the summer nursery. These were all derived from the cross Arabian × Sernai Caieh and are high-yielding, early maturing, stiff-strawed selections. In 437 segregating populations received from the Mexican program, not one plant was found to be resistant to stem rust, but about 180 dwarf durum types were selected.

Composite or Multilineal Varieties

Until recently composite or multilineal varieties had not been developed in Chile, primarily because no suitable variety for the recurrent parent was available. Among the introductions from the Colombian and Mexican programs grown in the nursery in 1959–1960, however, were lines developed for use in multilineal varieties in those countries. From this material, a total of 58 composites, representing the varieties Frocor, Lerma 52, and Yaqui 50, was formed for testing in Chile. These multilineal varieties yielded up to 36% more than the recurrent variety, up to 30% more than the average of the lines entering the composite, and up to 15% more than the highest-yielding line in the composite. The fact that these results were obtained under rust-free conditions suggests that, in addition to having an insurance factor against losses from disease, multilineal varieties may offer yield advantages over standard varieties.

Adaptation Trials

A standard, replicated yield trial of 25 spring wheats, including all the spring wheat varieties grown in the northern zone and four selections from the program, was grown at six locations. Two of these were dryland plots near Santiago, one in the humid coastal area and the other in the dry central valley; two irrigated plots were also located near Santiago. The other two irrigated plots were located one at the southern limit of the zone near Talca, the other near Ovalle at the northern limit. The results of the trial showed that at all locations the new varieties and selections developed by the Office were superior to the older varieties, the implication being that early maturing varieties are better suited than late ones for this zone.

INTERMEDIATE WHEAT ZONE

Investigations for the intermediate wheat zone are concentrated at the Central-South Experiment Station at Chillán. This station serves the area between the provinces of Talca and Malleco in which about 209,000 hectares of wheat are grown annually. Both the winter wheats of the south and the spring wheats of the north are grown in this zone. The low average yields of about 800 kg./ha. obtained are due to poor soils, poor cultural practices, and the lack of proper varieties.

The main disease problems in this area are stripe and leaf rust. Without seed treatment, common bunt is also a serious problem. Other important diseases are Septoria blotch and root rot. Stem rust occurs only sporadically.

Wheat varieties for this area should head in early November from either a fall or spring planting to avoid late spring frosts at flowering. They should then mature rapidly to utilize available soil moisture if grown under dryland conditions. They should also have short, stiff straw and a deep root system to prevent lodging from strong wind gusts.

A number of the spring wheats from the northern zone, when sown in late August, meet these requirements. Of the 486 varieties in yield trials, 20 outyielded Chifén and have been selected for preliminary multiplication. Outstanding among these were five semi-dwarf lines from the cross Yaktana 54 × Norin 10-Baart made in Mexico.

No yield data are available for fall-planted spring wheats in this zone, but many of the spring wheats in the crossing block developed vigorously and had an acceptable heading date when sown in early May. A number of spring type, semi-dwarf lines in the segregating material showed outstanding adaptation. These wheats have excellent resistance to lodging, good tillering and disease resistance, and mature rapidly after heading. Forty-six of the more uniform rows were cut for next year's yield trials at the three main stations.

The new hybrid combinations made at the Chillán station consist of crosses between spring wheats and winter wheats to combine the best features of each parent. From this material, it is expected that new varieties will be produced not only for this zone, but also for the north and for the south. During the year over 300 spring-winter crosses were made.

Southern Wheat Zone

Investigations for the southern wheat zone are centered at the Southern Experiment Station near Temuco. This station serves the area south of Bío-Bío province in which about 436,000 hectares of wheat are grown annually. Yields of 5 tons/ha. are not uncommon in parts of this zone.

Most of the area is sown to wheat varieties of European origin having a winter growth habit. Cappelle Desprez and Vilmorin 29 are the most widely grown and are used as check varieties in the program. Other winter varieties grown in the zone are Nord Desprez, Marne Desprez, Artois Desprez, Vilmorin 53, Heine IV, and Heine VII. Although club wheats were introduced to the western United States from Chile, they are now found only in small plots of mixed wheats cultivated by Indians in this zone.

Rains frequently delay planting until late winter or early spring. Vilmorin 29 is commonly used for these late plantings. Increased acreages of sugar beets and rape are presenting farmers with a rotation problem which could be solved by planting high-yielding spring wheats. About 5% of the wheat area in the zone is sown to spring wheats of uncertain identity, such as Manitoba, Trigo Ruso, and Primavera de Osorno.

CULTURAL PRACTICES

A date-of-seeding experiment conducted at Temuco during the report period showed that the best yields of six winter wheat varieties were obtained from a mid-May planting, and the best yields of four spring wheat varieties from mid-August plantings. It was established in this experiment that the early maturing winter variety, Etoile de Choisy, was not suited for a late planting in this zone. Root rot caused large reduction in yield of all varieties in the early plantings.

The best rate of seeding was found to be 120 kg./ha., or exactly half the amount most commonly used by farmers in the zone. The reasons for the use of the high seeding rate of 240 kg./ha. are not known. Before a general recommendation of the lower rate can be made, results from several years' trials at different locations are needed.

TABLE 1.

Performance of better winter wheat varieties in yield trials at the Southern Experiment Station, 1960-1961.

	REACTION TO		DAYS TO		
Variety	Stripe rust	Leaf rust	Heading	Plant height (cm.)	Yield
Vilmorin 53	MS[a]	S	200	120	120[b]
Druchamp	0	S	203	120	112
Alter de Gembloux	0	S	199	120	110
Artois Desprez	0	S	201	115	107
Marne Desprez	0	S	204	125	107
Nord Desprez	MS	S	201	105	104
Pax Cambier	S	S	202	110	103
Biofén	MS	S	201	125	102
Vilmorin 29 (Regional variety)	MS	S	205	130	102
Cappelle Desprez (Regional variety)	MS	S	205	110	100

[a] MS = moderately susceptible; S = susceptible.

[b] Expressed as percentage of Cappelle Desprez, which yielded 4,508 kg./ha.

VARIETAL IMPROVEMENT

The French varieties Ardennes Desprez, Elite Lepeuple, Heurtebise, Maitre Pierre, and Poncheau, tested in Chile for the first time this year, all showed good adaptation and disease resistance. Small multiplication plots of these varieties will be grown in the next season while further data on their performance are collected.

Yields of up to 28% more than that of Cappelle Desprez were found among the wheats in yield trials; the performance of the better winter wheats is shown in Table 1. Most of these wheats have obvious defects which prevent their use as recommended varieties in the zone, but which can be improved upon by hybridization. Vilmorin 53, for example, an excellent wheat in many respects, cannot be recommended because it is susceptible to shattering. It has therefore been crossed with Rulofén to combine factors for adaptation in the zone with excellent resistance to shattering.

More than 1,000 crosses between winter wheats were made during the year. Nearly half of these involved new combinations with dwarf wheats having factors for improved straw and high yield. About 180 of the crosses were made with the objective of combining factors for good adaptation and good quality, and another 400 were made in order to transfer factors for disease resistance into otherwise well-adapted wheats.

In general, most of the 486 northern spring wheats tested at Temuco headed too early to be suited for the zone, and furthermore lacked the vigorous growth and tillering associated with good adaptation. Nevertheless, 48 of the entries yielded more than 3.5 tons/ha. The best yield, 4.4 tons/ha., was produced by the same semi-dwarf line that had the best yield at Chillán.

Under development are rust-resistant spring types of six French winter wheat varieties. The original crosses were made between the French varieties and rust-resistant spring wheats, and the winter wheats are being used as the recurrent parent in subsequent crosses with the rust-resistant spring wheat progeny. This project is at the stage of the second backcross. It is expected that after one or two additional backcrosses to the French variety, well-adapted spring wheats for the zone will be developed.

FARINOLOGY

The investigations of the farinology laboratory are directed primarily to determining some of the physical-chemical characteristics of new lines and varieties of wheat from country-wide trials. Among the data taken on whole grain are: weight, protein content, Pelsheske results, and hardness. Flour from the experimental mills is used for rheological tests in a mixograph or a farinograph and to bake experimental loaves. An analysis of a sample may contain as many as 34 observations.

The results of these tests permit the selection of good-quality wheats that may be used either directly as commercial varieties or as parents for new varieties. Of about 1,500 samples of wheat varieties adapted to the northern wheat zone, more than 90 have good to excellent quality. This demonstrates that it is possible to combine good quality and high yield in the wheats for this zone.

PATHOLOGY

The greenhouse facilities at the new stations have permitted a more intensive search for disease-resistant wheats. Testing of selected material in the seedling stage for rust resistance was begun during the year. Mixtures of races or individual races of stem and leaf rust are used to select the wheats with the best resistance.

From collections made during the year, races 11, 14, 15, 15B, 17, and 29 of stem rust were identified. A new race of stem rust, virulent on Candealfén, was identified as a biotype of race 15. Two races of leaf rust isolated from collections made during the year correspond to races 67 and 107.

Studies with stripe rust, the most important wheat disease in the south, were begun this year. In a student's thesis project it was discovered that stomatal exclusion operates against stripe rust on peduncles and sheaths of vigorously growing wheat plants. This explains why in certain varieties stripe rust is absent on these parts when the leaf blades and glumes are severely infected.

Steers grazing on the experimental pasture at Chillán.

Forage

Four years of forage research under the direction of the Office of Special Studies have now been completed. With the information available on yields, disease resistance, and stand longevity, sound recommendations can be made on species, varieties, methods and time of seeding, fertilization, and general pasture management.

During the year, two legume varieties, Moapa alfalfa and Clare subterranean clover, have been recommended for importation and use in Chile on the basis of superior performance in three years of yield tests. Moapa, a non-winter-hardy variety of alfalfa developed for the southwestern United States, is well adapted in the irrigated central valley of Chile, where it is recommended for rotations requiring not more than four years of forage. Clare, a subterranean clover variety recently developed in Australia, has consistently been the highest yielding variety in regions of Chile with an average of 350–750 mm. rainfall; its flowering date and seed set assure annual reseeding in these areas.

In addition, three new legumes have been multiplied in sufficient quantity for release to selected certified seed producers for planting during the 1961–1962 season. (1) Quiñikeli ("number one, red") is the first red clover variety to be developed in Chile. It has been selected from over 50 local strains for its high seedling vigor, fast recovery after cutting, and relatively good resistance to rust; in tests, it has been superior to all introduced varieties in seedling vigor and total yield. (2) Kimey ("good") is a high-yielding, upright strain of birdsfoot trefoil (*Lotus corniculatus*) selected from seed introduced from Brazil. It will be recommended as a long-lived, deep-rooted legume for semi-permanent pastures in southern Chile, where alfalfa cannot be used. (3) Ligüen ("early") is a fast-growing, high-yielding, nonhardy variety of alfalfa selected from seed imported from Israel. Its probable origin is Hairy Peruvian, but in trials near Santiago it has recovered faster and yielded more than any other variety or strain; it also begins growth earlier in the spring and continues later into the fall than any other variety tested. Ligüen will be recommended for use in short rotations from Curicó province north.

During the period covered by this report, expansion of the forage program consisted principally of the addition of a new dryland location in Valparaiso province, a marked increase in soil fertility research, and the development of a research-demonstration program in Valdivia and Osorno provinces, an important grassland area.

Irrigated and Rainfed Regions

LEGUME AND GRASS IMPROVEMENT

Owing to limitations in facilities and number of personnel, the breeding effort has been concentrated on the two major legumes and two major grasses: alfalfa (*Medicago sativa*), red clover (*Trifolium pratense*), orchardgrass (*Dactylia glomerata*), and ryegrass (*Lolium multiflorum* and *L. perenne*).

F_1 alfalfa plant from a cross between a creeping-rooted parent and an erect nonhardy parent.

Alfalfa

The two main objectives of the alfalfa improvement program, which is centered at Santiago, are greater longevity of stands and increased production at low temperatures (winter vigor). Since preliminary studies and observations indicate that both stem and root-knot nematodes present serious problems in stand maintenance, an extensive project has been initiated that involves (1) a survey of the prevalence of these two nematodes, (2) development of inoculation techniques, (3) study of the cross-inoculation of several forage species with individual collections made from the same and other species, and (4) testing of varieties and breeding materials in the field and greenhouse for nematode resistance. Several collections of nematodes from alfalfa and red clover in different areas have been sent to the U. S. Department of Agriculture, Beltsville, Maryland, for identification.

Varieties that start growth early in the spring and continue late in the fall, when temperatures are still too low for most of the established varieties, are needed to provide feed during this critical period of feed shortage. At present, the most promising breeding material is found among the nonhardy varieties, such as the Israel Selection out of Hairy Peruvian, Moapa, Indian, African, and other Peruvian and Chilean selections. None of these varieties has any appreciable resistance to nematodes. However, the variety Lahontan, although it is too winter-dormant to be desirable, possesses a high level of resistance to stem nematodes, and sources of resistance to the root-knot nematode are also available. Both kinds of resistance will be introduced into the nonhardy material.

A second approach to the problems of winter growth and longevity is being made through the introduction of the creeping-rooted habit into the varieties Indian and African. The creeping-rooted parents were selected in Chile from the same material from which the Canadian variety Rambler was selected. More than 900 F_1 plants from these crosses have been evaluated for the creeping-rooted habit, winter vigor, and disease resistance, and 59 clones have been selected for further evaluation.

Red Clover

Red clover is widely adapted in Chile, but since it is the major forage legume in most of the southern part of the country, the breeding program is located at Temuco. The objectives are essentially the same as for alfalfa, but the problem of stand longevity is considerably more serious in red clover. In the irrigated areas of the central zone and in many of the nonirrigated areas to the south, economic stands of more than three years of age are uncommon.

Three local selections—Curicó, Teno, and Chimbarongo—and three introduced varieties—Reinholdt, Stevens, and Pennscott—have performed well in many trials, and controlled cross-pollinations have been made between these two groups in an attempt to combine the vigor and productivity of the former with the earliness of the latter. These 6 varieties, plus 12 others, are being grown in a spaced nursery of over 20,000 plants, all of which will be evaluated for disease resistance, winter growth, and recovery after cutting. Material immediately available for selection includes an older spaced nursery of two Chilean strains and 3,000–4,000 miscellaneous plants.

Orchardgrass

The improvement program for this grass is located at Chillán, which is centrally situated in the orchardgrass belt. Immediate objectives are breeding and selecting for increased winter and summer vigor and for resistance to rust and several foliar diseases.

Considerable variation in late fall and early spring growth exists among clones in space-planted nurseries. Several clones showing excellent winter vigor have been selected from a nursery of local material at Chillán, and these are now being polycrossed to provide material for further selection. These clones have also been separated into three maturity groups for a study of the relation between winter vigor and maturity as measured by date of heading. Other material available at Chillán includes the USDA, Mediterranean (FAO), and California collections of orchardgrass.

The striking differences in appearance and performance between plants growing in clonal or wide-spaced row nurseries and those growing in solid stands suggest that the orchardgrass plot trials are not measuring the potential differences of the varieties and lines. At Osorno, Temuco, and Chillán, heavy topdressing with nitrogen, phosphorus, and sulfur has not improved performance or appearance of varieties. To provide an effective method of comparing varieties and lines, studies have been initiated to determine the effect of different plant populations and different levels of organic matter on varietal performance.

Ryegrass

The immediate aims of the ryegrass improvement program are to combine the seedling vigor and rapid growth of *Lolium multiflorum* with the perennial habit of *L. perenne*, to select for more summer vigor, and to combine adequate rust resistance with other desirable characters. Because of the shortage of personnel, this work is not yet fully under way.

VARIETY TRIALS

After three years of concentrated testing, the varietal needs and limitations of the major agricultural regions of central Chile have been fairly well determined. Although the basis thus exists for recommendations of new legume varieties, to date no varieties have been found, except in ryegrass, that are better than the ones currently in use.

Alfalfa

In trials in the Santiago region, the nonhardy alfalfas have consistently yielded up to 20% more than the commonly grown variety, Caliverde; selected data from a trial of 25 entries are given in Table 1.

The major problem is stand maintenance. Both stem and root nematodes are prevalent from Curicó province to the north, where in areas seriously infested with stem nematodes, stands are sometimes eliminated after the second harvest year. For the present, the only recommended varieties for which seeds are available to the farmers are Caliverde and Moapa. The new variety Ligüen will have to undergo at least two more years of multiplication before seed will be generally available.

Stand maintenance is also the main problem in the Chillán area, and no variety is currently recommended there. The European varieties Franconia, Provence, Du Puits, and Scandia

TABLE 1.

Green weight yields of five most productive alfalfa varieties and Caliverde. Santiago, 1960.

Variety	YIELD Ton/ha.	YIELD % of Caliverde	No. cuttings in one year
African	148.5	127	8
Israel	146.6	126	8
Moapa	138.8	119	8
Peruana Arizona	138.7	119	8
Terra Verde	137.9	118	8
Caliverde	116.7	100	7

and the Peruvian alfalfas have shown the best adaptation in trials. The more nonhardy varieties, which produce well in the Santiago region, are quite susceptible to leaf and stem diseases in late fall and early spring at Chillán.

Red Clover

Local strains of red clover have generally outperformed all imported varieties. As noted earlier, one of these, Quiñikeli, is now being multiplied for release; at present, there is seed available to plant 50 hectares. Next to the local strains, the varieties Reinholdt, Stevens, and Pennscott from the United States and two Italian strains have been the most promising. In contrast to other species, red clover varieties maintain their relative rank of performance throughout Chile.

White Clover

The vigorous Ladino varieties continue to show superiority in clipping trials (Tables 2 and 3), and also are as drought-resistant as any other variety or type. In line trials, however, the New Zealand strains have spread faster, a characteristic that may be important where droughts are prevalent and rapid spread after a drought is needed. For the present, locally produced certified Ladino and New Zealand are the only varieties recommended. Trials are being planned to test the productivity of the different types under grazing.

Swollen stems and chlorotic leaves are typical symptoms of stem nematodes in alfalfa.

Trefoil

Birdsfoot trefoil continues to show promise as a long-lived, deep-rooted legume for southern Chile. In clipping trials, *Lotus corniculatus* has been the most productive, even though *L. uliginosis* and *L. tenuis* are commonly found growing wild. Upright-growing strains from Brazil and Argentina have been the easiest to establish and the highest yielding. The release of the new variety Kimey will mark the first time that a variety of trefoil has been recommended in Chile.

TABLE 2.

Green weight yields and rank of white clover varieties clipped over a two-year period. Chillán, 1960.

Rank[a]	Variety	YIELD Ton/ha.	YIELD % of N. Zeal. White
1	Caladino M-1	125.2	161
2	Ladino common Chimbarongo	111.5	144
3	Ladino Bohnert	109.8	142
4	Vermont Polyploid	109.4	141
5	Ladino common Chillán	107.7	139
25	New Zealand White	77.5	100

[a] Trial of 29 entries.

TABLE 3.

Green weight yields and rank of white clover varieties clipped over a two-year period. Osorno, 1960.

		YIELD	
Rank[a]	Variety	Ton/ha.	% of N. Zeal. White
1	Caladino	43.6	114
2	Northern Italy	40.1	107
3	Caladino M-1	39.7	106
4	Ladino common Chillán	39.5	106
5	Caladino B-1	38.9	104
8	New Zealand White	37.4	100

[a] Trial of 25 entries.

Grasses

Although no specific perennial variety of ryegrass is currently recommended, Short Rotation, an Australian variety from a cross between annual and perennial species, acts as a perennial in Chile and has outyielded both annuals and perennials in tests of over two years' duration (Table 4). Although, as the table shows, some of the local strains have yielded quite satisfactorily in comparison with Short Rotation, these cannot be certified since they are mixtures of annual and perennial species. Two annual species from Holland, Dutch Seempter and Dutch Mommersteeg, have been outstanding at all locations.

Other species being tested include orchardgrass, tall fescue, Hardinggrass, forage sorghums, and sudangrass.

MIXTURE STUDIES

Forage mixture studies have been made at all major locations and also are included in a number of field trials in the Osorno and Valdivia regions. In the following brief summaries of the data by station, it should be noted that all evaluation has been made through clipping trials, which naturally favor the erect-growing plants, such as alfalfa and red clover.

Santiago

For hay production, no mixtures have been superior to alfalfa or red clover grown alone. For direct and full-season grazing, Ladino

TABLE 4.

Green weight yields of ryegrass varieties clipped over a two-year period. Osorno, 1958–1960.

Rank[a]	Variety	Yield (ton/ha.)	Type of growth
1	Short Rotation	71.4	Hybrid (Perennial × annual)
2	Frutrono[b]	70.4	Mixture (annual & perennial)
3	Dutch Seempter	62.2	Long-lived annual
4	Valdivia[b]	58.7	Mixture (annual & perennial)
5	Puyehue[b]	48.5	Mixture (annual & perennial)
6	Río Negro	48.0	Mixture (annual & perennial)
7	Certified USA	48.0	Perennial
8	Dutch Mommersteeg	45.9	Long-lived annual
9	Colac	45.7	Perennial
10	Clunes	44.9	Perennial

[a] Trial of 25 entries.

[b] Seedlots produced in Chile; name indicates locality of production.

clover is the best legume when irrigation water is abundant, and it can also be used in poorly drained soils where alfalfa will not persist. Orchardgrass, ryegrass, and fescue all do well with clover in this region if properly managed.

Chillán

In mixture studies, production has depended principally on the legume fraction. Among the legumes tested under irrigation, the best overall yields have been obtained from red clover. The best legume for grazing in this area, if soil moisture is continuously available, is white clover; a mixture with ryegrass, orchardgrass, or tall fescue helps to reduce the danger of bloat. Ryegrass best fits the management scheme of white clover but tends to become dormant during the hot weather of January and February. In tests of Hardinggrass-Ladino mixtures, Hardinggrass has given excellent late fall and early spring growth but has yielded even less than ryegrass in summer.

Both alfalfa and birdsfoot trefoil are difficult to establish in this area.

Temuco

With only 5% of the land in this region under irrigation, mixtures suitable for the nonirrigated areas are the most important. Although in theory alfalfa could fill the need for a deep-rooted, drought-resistant legume, there are difficulties in stand establishment, and red clover therefore remains the best legume. It grows well with orchardgrass, tall fescue, and ryegrass.

Birdsfoot trefoil has given good results when seeded alone or with reduced seeding rates of grasses, but more data are needed on establishment and management before it can be generally recommended. In areas where soil moisture is available throughout the year, white clover is the best forage for grazing; it does well in association with ryegrass, fescue, and orchardgrass.

Mt. Barker and Tallarook subterranean clover may also be used in this area. For mixtures, Hardinggrass, tall fescue, or orchardgrass is recommended.

Valdivia and Osorno

Data indicate that red clover should continue as the recommended legume in areas where summer droughts occur, at least until establishment problems with alfalfa or birdsfoot trefoil are solved. Mixtures with orchardgrass, ryegrass, or tall fescue are recommended in this region. White clover, an important legume where soil moisture is available and fertility levels are adequate, grows well in mixtures with ryegrass, fescue, or orchardgrass. In arid or semi-arid soils, subterranean clover, especially the variety Tallarook, shows promise in mixtures with Hardinggrass, tall fescue, or orchardgrass.

SOIL FERTILITY

Adequate use of fertilizer appears to be the fastest way of increasing forage production in Chile. Experiments planned by Dr. James Menzies, Temporary Scientific Aide, have shown that near normal stands and yields of alfalfa can be obtained at both Temuco and Chillán with proper phosphorus fertilization. It can be seen in Table 5 that 80 kg./ha. of P_2O_5 bandseeded (placed in the row slightly below the seed) gave yields essentially equal to those obtained with 350 kg./ha. broadcast (spread uniformly over the soil and worked into the top 8 inches prior to seeding). A combination of the two treatments increased the yield still further. The fact that the same experiments failed at Osorno because of poor stand establishment suggests that a different problem exists there.

TABLE 5.

Green weight yields (ton/ha.) of alfalfa as affected by phosphate fertilization. Chillán and Temuco, 1960–1961.

	YIELD	
P_2O_5 applied (kg./ha.)	Chillán	Temuco
Check	8.0	8.5
80 bandseeded	13.4	20.2
350 broadcast	13.6	21.7
80 bandseeded + 350 broadcast	17.4	30.7

Application of limestone ($CaCO_3$ or $CaOH_2$) at rates of up to 12 tons/ha. doubled the yield at Temuco but had no measurable effect at Chillán (Table 6). In contrast to results obtained in Australia, application of small quantities of limestone (100 kg./ha.) in the row always decreased yield, regardless of the amount of phosphate applied.

Rapid phosphorus tie-up is also a problem. At Chillán, a three-year experiment was conducted to test the effect of different amounts of phosphate fertilizer applied at the time of seeding on the yields of a Ladino clover-orchardgrass-fescue mixture. After the second harvest year, the effect of phosphorus was negligible, even when 300 kg./ha. of P_2O_5 had been applied at the time of establishment.

TABLE 6.

Green weight yields (ton/ha.) of alfalfa as affected by liming ($CaCO_3$) when adequate phosphate was applied, Chillán and Temuco, 1960–1961.

Lime applied (kg./ha.)	YIELD Chillán	 Temuco
0	17.8	15.7
800	17.3	20.0
1,600	18.2	20.8
3,200	16.6	21.9
6,400	19.0	26.0
128,000	19.3	31.0

Other striking responses to fertilization have been noted. Near Osorno in September, 1960, more than 19 tons/ha. of green material were clipped from a well-fertilized mixture of red clover-ryegrass-Hardinggrass, but plots not receiving phosphorus gave zero yield. In Valdivia province, application of 64 kg./ha. of elemental nitrogen more than doubled the green weight yield (15 tons vs. 31 tons) of a

At Osorno, a fertilized mixture (left) of red clover-ryegrass-Hardinggrass yielded over 19 tons of forage; the check plot gave no yield.

natural pasture, and 75 kg./ha. of P_2O_5 produced good stands of a white clover-ryegrass-orchardgrass mixture on a lowland soil high in organic matter; without phosphate, however, both the legume and the grasses failed to become established.

Response to potash is evident in the Valdivia area, but only where the phosphate level is adequate. In one trial, the only plots with good stands of red clover after the second harvest year were those that had received both potash and phosphate fertilizer. Sulfur application gave a noticeable increase in subterranean clover growth at Cauquenes and in alfalfa growth at Osorno, but again, only when adequate phosphorus had been applied.

The new greenhouses at the Santiago and Temuco stations have been used to conduct preliminary fertility trials on key soils prior to the planning of field experiments. The general response to phosphate fertilization has been the most striking observation from these trials. When grown in soils from the Santiago area, a region normally considered only slightly deficient in phosphorus, alfalfa responded to applications of up to 400 kg./ha. of P_2O_5 and orchardgrass showed no response to nitrogen unless phosphate fertilizer was used. These results are quite uncommon in studies with grasses alone and indicate an extreme phosphorus deficiency.

GRAZING TRIAL

In trials conducted at Chillán in cooperation with the Animal Science Department of the University of Concepción, over 1,000 kg. of beef per hectare were produced in only 126 days by grazing steers one to two years of age on a white clover-ryegrass pasture, without supplemental feeding. During the 1959–1960 season the same pasture gave a yield of over 900 kg. of beef per hectare in 224 days; in that season, however, older animals (two to three years) were used and pasture management was inferior. This experiment was initiated to study the effect of rotation versus continuous grazing, but the differences in daily gain and total yield in favor of the rotation system have proved very slight. The most striking observation has been the high total yields under both systems; in 1960–1961, 1,211 kg. of beef per hectare were produced with rotation grazing, and 1,144 kg. with continuous grazing.

During the past season, another variable has been added to the experiment—nutritional level of overwintering. Data obtained in the first 154 days indicate marked differences in daily individual gain, and consequently in yield per hectare, among tester steers that were rated very thin, intermediate, or fat at the start of the trial. Although more information is needed, it would appear that the most economical practice is that which permits maximum gain to be produced on pasture rather than on high-priced stored feeds during the winter. This trial will be continued at least through the 1961–1962 season.

DRYLAND REGIONS

The new field location established near Concón, Valparaiso, is representative of sandy soils formed from granitic rock. The soils here are generally badly eroded and quite low in natural fertility.

Forage production in the dryland regions was seriously reduced during the past year because of a general drought. Effective rainfall did not occur until June, by which time the temperature had fallen, and little or no growth took place until spring.

VARIETY TRIALS

Alfalfa was the only perennial species on which varietal information was collected in 1960. Because of the late fall rains, the nonhardy varieties yielded less well than in previous years, and the check varieties, Alta Sierra, Caliverde, and Peruana, equaled the rest in yield. In new trials seeded in 1960, the nonhardy varieties had better seedling vigor, which was a definite advantage in weed competition.

As a result of the drought, it was possible to delineate the limits for recommending varieties of subterranean clover. On the basis of both total yield and reseeding ability, the recommendations are: Dwalganup for areas with less than 350 mm. average annual rainfall; Clare, 350–750 mm. rainfall; Mt. Barker, 500–1,200 mm. rainfall; and Tallarook, over 1,000 mm. rainfall.

Variety trials at the Concón and Santo Domingo stations show that crimson clover does very well in the coastal dryland regions. Dixie, the only variety recommended at present, produced good yields in both trials. In two experiments with different species and strains of vetch (*Vicia*), the *sativa* and *atropurpurea* species gave equally good yields at Concón, but *atropurpurea* was much superior at Santiago. Although no certified varieties are available, the vetches can be used as annual legumes to give an abundance of good-quality forage.

MIXTURE TRIALS

Data obtained from mixture trials indicate the value of legumes as a base for dryland forage seeding. Not only do legumes yield well, they also eliminate the need for nitrate fertilization in these normally quite infertile soils.

Where it has been possible to establish it, alfalfa has given high yields and remained productive longer than any other species. In deep soils, it has yielded better than any mixture. Hardinggrass appears to be the best grass to grow with alfalfa in dryland regions.

Subterranean clover is the most widely adapted dryland legume and does well as far south as Osorno, in areas not normally classified as dryland but that often have extended summer drought. On fertile soils with adequate moisture, a mixture with Hardinggrass has given good results; Wimmera ryegrass makes a better component in the mixture in the drier areas.

Crimson clover has done especially well on the coastal soils near Concón and Santo Domingo. It can be established with wheat as a companion crop and is normally seeded alone owing to its habit of growth and the necessity for annual reseeding.

Small grains, or a mixture of rye or oats and annual vetch, have given excellent yields and can probably utilize the winter rainfall more efficiently than any other mixture. Over 30 tons/ha. of green forage were produced at Concón in 1960 with only slightly over 200 mm. rainfall. These mixtures must be seeded annually but can furnish material for silage to be used as a supplemental feeding during the dry summer months.

Parshall flume and concrete lined canal, Santiago.

Experiment Station Development

In 1959, the Ministry of Agriculture purchased land for two new regional research centers: the Central Experiment Station near Santiago and the Southern Experiment Station near Temuco. During the past two years, the Office of Special Studies has collaborated closely with the Ministry in planning and developing these two new stations.

Central Experiment Station, Santiago

CONSTRUCTION

The administration building, the U-shaped laboratory building, the greenhouse-headhouse, and the station cafeteria are being constructed under a private contract let by the Ministry of Public Works. Occupancy of these buildings is scheduled for December, 1961. Construction of a combination farm and carpenter shop is also nearing completion. An 8-foot chain-link fence with reinforced concrete posts is being erected around the farm machinery area in order to eliminate excessive traffic and make control of the equipment easier.

Two greenhouses equipped with central heating and water are now in use by the crops research sections, and electrical wiring will be installed within the next two months, in time for winter research studies under artificial light. The foundations and galvanized steel structures for a third and fourth greenhouse have been completed, with some additional work having been done on the third.

The future animal research buildings have been designed under the direction of Mr. Norval Curry, formerly head of farm structure in the Department of Agricultural Engineering, Iowa State University, and now a private consultant, who spent seven weeks in Chile during February-March, 1961. General plans for the research program were first formulated by members of the Office of Special Studies with the aid of Dr. Mario Cornejo, head of the Department of Animal Husbandry in the Ministry of Agriculture. On the basis of this information, Mr. Curry then designed the research unit and recommended appropriate installations and equipment; during a two-week period he was assisted by Dr. James Fransen of the Foundation's Colombian program. It is planned to expand the building and research activities by stages in order to develop a program in the shortest period of time and with a nominal capital outlay. To this end, construction and operation of production facilities for the maintenance of herds will be delayed until additional trained technical personnel are available.

UTILITIES

A 4-inch transit water main has been connected to the farm shops and greenhouses from the municipal water supply of Santiago. Since this water supply is limited and undependable, however, a 630-foot well has been drilled that has a capacity of 7 gallons per second; this will be used to supply the principal buildings and will allow a limited amount for irrigation.

During the past year, a 100 KVA transformer was installed within the construction area of the station and electrical power is now being used. Expansion plans include a high-tension line to the deep well and to the projected warehouse, and exchange of the present 100 KVA transformer for a 150 KVA unit; these power lines have been designed and will be installed shortly. The 100 KVA transformer will be used in the future animal research unit.

FIELD OPERATIONS

The job of removing the many thousand cubic meters of stone walls has continued during the year when workers were available for this activity. A rock crusher has been ordered to permit the use of rocks collected from the fields for road-bed material. Trees and trunks still existing along the central canal are being removed as workers are available.

During the summer months, 55 hectares of land were leveled, of which 45 hectares are now ready for irrigation, with permanent borders completed.

A parshall flume, coupled with two distribution gates, has been completed, and during June and July, when the irrigation water is normally discontinued for canal cleaning, a section of concrete-lined canal will be installed above the flume. Approximately 800 feet of concrete-lined canal and one concrete drop have been built at the east side of the station, extending north from the parshall flume. Another 2,400 feet of concrete-lined canal will be added during the coming year.

The new road network makes movement and communication within the station possible, but a road surface stabilizer must be used because of the serious dust problem.

Owing to the proximity of the station to metropolitan Santiago, an 8-foot galvanized link fence is being constructed around the station. The fence is supported by concrete posts, moulded at the station and using a minimum of expensive reinforced rods. Along the north line of the station, nearly 2,000 feet of fence posts have been located and concreted in place.

SOUTHERN EXPERIMENT STATION, TEMUCO

With the purchase by the Ministry of Agriculture of an additional 105 hectares of land adjoining the west side of the station, the total land area is now 335 hectares. In the near future a topographical map will be made of the new area, so that roads, canals, and drains can be designed and developed.

CONSTRUCTION

Detailed floor plans showing all furniture and plumbing and electrical outlets have been submitted to the architectural firm that designed the main building, and the building plans can now be sent out for bids. It is anticipated that the contract will be let and construction started during 1961. As at Santiago, the Ministry of Public Works will supervise the construction.

Two greenhouses are already in use by the crops research sections. Both are equipped with water and in one the supports are in place for the central heating system. Power will be installed soon, so that light will be available for research studies during the short winter days.

Dr. Fransen and Mr. Curry have made a complete set of general floor plans and building layout for the animal research buildings at this station.

UTILITIES

The drilling of a deep well for the principal buildings was started in January, 1961. CORFO, a cooperating governmental agency, is using this operation as an exploratory test for the Temuco area and will drill beyond the necessary depth in an attempt to reach an artesian well. A second well is to be drilled on the site of the future animal research buildings.

A 300 KVA transformer has been connected within the station to the new power line from Temuco. At present, the power is connected to the existing warehouse and is being extended to the greenhouses, farm shop area, gas pumps, and future laboratory buildings.

FIELD OPERATIONS

Additional work has been done on the canal and the swampy area running through the rear of the station. The level of the drainage ditch was dropped 10 inches in an attempt to drain more of the swampy area. Also, more tree trunks and roots have been removed. (It is interesting to note that a farmer adjacent to the station is following the example set by the station last year and is removing old tree stumps and some trees from his pastures and fields. He apparently has seen the advantage of having cleared fields, especially when using large field machinery.)

Even though the dry season is much shorter at Temuco than at Santiago, some 400 hectares of land were floated with a 40-foot Eversman land leveler and borders were constructed on 20 hectares.

Mr. James L. Myler, Director of Field Stations for the University of California, visited the program in October and November, 1960 as a Temporary Scientific Aide for the second time to advise on problems of land leveling and irrigation. During his stay, he assisted in setting up a field demonstration of border irrigation at the Southern Experiment Station, and also spent many hours with the station agronomists working out other irrigation details.

The new road network has facilitated movement and communication within the station, but, as at Santiago, a road surface stabilizer must be used because of the dust problem.

Indian Agricultural Program

Personnel

COOPERATING AGENCIES
INDIAN AGRICULTURAL PROGRAM

MINISTRY OF FOOD AND AGRICULTURE

Shri S. K. Patil, Minister for Food and Agriculture
Dr. P. S. Deshmukh, Union Minister for Agriculture
Shri K. R. Damle, I.C.S., Secretary to Government of India, Ministry of Food and Agriculture
Shri S. Mullick, I.C.S., Joint Secretary to Government of India, Ministry of Food and Agriculture
Shri Krishan Chand, I.C.S., Joint Secretary to Government of India, Ministry of Food and Agriculture
Shri D. Ramiah, Deputy Secretary to Government of India, Ministry of Food and Agriculture
Dr. G. V. Chalam, Deputy Agricultural Commissioner, Ministry of Food and Agriculture
Shri A. C. Jain, Under Secretary to Government of India, Ministry of Food and Agriculture
Shri I. P. Mathur, Under Secretary to Government of India, Ministry of Food and Agriculture
Shri R. M. L. Vaish, Under Secretary to Government of India, Ministry of Food and Agriculture

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Shri V. Shankar, I.C.S., Vice-President, ICAR, and Special Secretary to Government of India, Ministry of Food and Agriculture
Dr. J. S. Patel, Agricultural Commissioner with the Government of India
Dr. S. M. Sikka, Additional Agricultural Commissioner with the Government of India
Dr. T. R. Mehta, Additional Agricultural Commissioner with the Government of India
Shri M. S. Pawar, Deputy Agricultural Commissioner
Shri S. K. Mirchandani, Secretary, ICAR, and Deputy Secretary to Government of India, Ministry of Food and Agriculture
Shri P. L. Malhotra, Administrative Officer, ICAR
Shri O. D. Garg, Section Officer, ICAR
Shri U. S. Jain, Section Officer, ICAR

INDIAN AGRICULTURAL RESEARCH INSTITUTE

Institute Council

Dr. B. P. Pal, Director

Dr. R. S. Vasudeva, Joint Director, and Head, Mycology and Plant Pathology Division

Dr. A. B. Joshi, Dean, Post Graduate School, and Head, Botany Division

Shri E. G. K. Rao, Head, Agricultural Engineering Division

Dr. A. R. Khan, Head, Agricultural Extension Division

Dr. O. P. Gautam, Head, Agronomy Division

Dr. E. S. Narayanan, Head, Entomology Division

Dr. S. K. Mukerjee, Head, Horticulture Division

Dr. C. Dakshinamurty, Head, Soil Science and Agricultural Chemistry Division

Dr. S. P. Raychaudhuri, Chief Soil Survey Officer

Shri Vas Dev, Registrar

Post Graduate Council

Dr. A. B. Joshi, Dean, Post Graduate School

Shri S. L. Vachher, Secretary, Assistant Registrar

Members

Dr. B. P. Pal, Director, IARI (Ex officio)

Dr. Ralph W. Cummings, Advisor, The Rockefeller Foundation (Ex officio)

Dr. S. L. Vishnoi, Professor of Agricultural Extension

Dr. O. P. Gautam, Professor of Agronomy

Dr. R. D. Asana, Professor of Botany

Dr. S. Pradhan, Professor of Entomology

Dr. G. S. Randhawa, Professor of Horticulture

Dr. K. C. Gulati, Professor of Soil Science and Agricultural Chemistry

Shri E. G. K. Rao, Head, Division of Agricultural Engineering

Dr. J. S. Patel, Agricultural Commissioner, ICAR (Coopted Member)

Dr. V. G. Panse, Statistical Advisor, ICAR (Coopted Member)

Dr. M. S. Swaminathan, Professor of Botany (Nominated from Post Graduate Faculty)

Dr. D. N. Srivastava, Professor of Mycology and Plant Pathology (Nominated from Post Graduate Faculty)

THE ROCKEFELLER FOUNDATION

R. W. Cummings, PH.D., Director, Indian Agricultural Program

G. B. Baird, PH.D., Assistant Director, Indian Agricultural Program

E. W. Sprague, PH.D., Geneticist and Coordinator, Maize Scheme, Indian Agricultural Program

B. L. Renfro, PH.D., Assistant Maize Breeder, Indian Agricultural Program

K. O. Rachie, PH.D., Geneticist and Sorghum-Millet Specialist, Indian Agricultural Program

L. R. House, PH.D., Associate Geneticist and Sorghum-Millet Specialist, Indian Agricultural Program

J. D. Traywick, M.S., Associate Agricultural Engineer, in charge, Experiment Station Operations, Indian Agricultural Program
W. M. Myers, PH.D., Temporary Staff Member, Visiting Professor, Post Graduate School (until June, 1960)
A. A. Johnson, M.S., Temporary Staff Member, Advisor on Seed Production

COORDINATED MAIZE BREEDING SCHEME

E. W. Sprague, PH.D., Coordinator, Geneticist, The Rockefeller Foundation
B. L. Renfro, PH.D., Assistant Maize Breeder
Shri D. N. Sajnani, Technical Assistant
Shri K. R. Chopra, Technical Assistant
Dr. B. S. Sidhu, Technical Assistant (until November, 1960)
Shri R. D. Bansal, Technical Assistant
Dr. G. D. Pershad, Technical Assistant
Shri V. L. Asnani, Technical Assistant

MAIN STATIONS

Indian Agricultural Research Institute

Dr. N. L. Dhawan, Associate Project Coordinator for Maize Scheme
(Vacant) Senior Maize Breeder
Shri Joginder Singh, Assistant Maize Breeder
Shri Amir Singh, Assistant Geneticist associated with the Maize Program
Shri S. M. Vaidya, Assistant Geneticist associated with the Maize Program
Shri Bhag Singh, Research Assistant
Shri S. S. Khurana, Research Assistant
(Vacant) Research Assistant

Hyderabad, Andhra Pradesh

Shri S. Vittal Rao, Senior Maize Breeder
Shri K. Narasimha Murthy, Assistant Maize Breeder
Shri S. Mahboob Ali, Research Assistant
Shri M. Ranga Reddy, Research Assistant
Shri K. Raj Reddy, Research Assistant

Srinagar, Kashmir

(Vacant) Maize Breeder
Shri R. N. Shangloo, Acting Assistant Maize Breeder
Shri Krishen Singh, Research Assistant
Shri Bashi Ahmad Khan, Research Assistant
Shri Shiben Kishen Mattoo, Research Assistant

Tarai State Farm, Uttar Pradesh

(Vacant) Senior Maize Breeder
Dr. P. S. Bhatnagar, Assistant Maize Breeder
Shri B. P. Pandya, Research Assistant
Shri V. P. Shukla, Research Assistant
Shri R. S. Gupta, Research Assistant

Gangtok, Sikkim

Shri J. K. Thapa, Assistant Maize Breeder
Shri M. B. Gurung, Research Assistant
(Vacant) Research Assistant

SUBSTATIONS

Ajmer, Rajasthan

Shri D. R. Bhandari, Assistant Maize Breeder
Shri K. L. Vyas, Research Assistant
Kumari T. Uma Devi Menon, Research Assistant

Almora, Uttar Pradesh

Dr. Boshi Sen, Director, Vivekananda Laboratory
Shri H. C. Joshi, Assistant Maize Breeder
Shri Basant Lal Verma, Research Assistant
Shri Bansi Lal Sah, Research Assistant

Arbhavi, Mysore

Shri R. N. Sangolli, Assistant Maize Breeder
Shri P. V. Hayavadan, Research Assistant
(Vacant) Research Assistant

Chhindwara, Madhya Pradesh

Shri K. K. Mandloi, Assistant Maize Breeder
Shri S. K. Dubey, Research Assistant
Shri S. V. Lokhande, Acting Research Assistant

Godhra, Gujarat

Shri K. M. Patel, Assistant Maize Breeder (until July, 1960)
Shri J. V. Majumdar, Assistant Maize Breeder
Shri B. C. Dave, Research Assistant
(Vacant) Research Assistant

Kalimpong, West Bengal

(Vacant) Assistant Maize Breeder
Shri S. N. Ghosh, Research Assistant
Shri S. S. Mahapatra, Research Assistant

Kangra, Punjab

Shri N. S. Gill, Assistant Maize Breeder
Shri Nirmal Singh Rangi, Research Assistant
Shri Surjit Singh Sandhu, Research Assistant

Naraingarh Farm, Punjab

Shri J. N. Batra, Assistant Maize Breeder
Shri V. P. Sood, Research Assistant
Shri Habir Singh, Research Assistant

Pusa, Bihar

Dr. Rameshwar Singh, Maize and Millet Specialist
Shri T. D. Jha, Assistant Maize Breeder
Shri P. N. Sinha, Research Assistant (until August, 1960)
Shri W. N. Jones, Research Assistant (until December, 1960)
Shri K. K. Srivastava, Research Assistant
(Vacant) Research Assistant

SORGHUM IMPROVEMENT PROGRAM

Indian Agricultural Research Institute

K. O. Rachie, PH.D., Coordinator, Geneticist and Sorghum-Millet Specialist, The Rockefeller Foundation
L. R. House, PH.D., Associate Geneticist and Sorghum-Millet Specialist, The Rockefeller Foundation
C. L. Dhawan, PH.D., Sorghum Botanist (PIRRCOM) (until February, 1961)
D. Srinivaschar, PH.D., Senior Cytogeneticist (PIRRCOM)
A. A. Sheth, PH.D., Technical Associate and Millets Field Collector (until April, 1961)
V. C. Shah, PH.D., Millets Field Collector (until April, 1961)
D. K. Nanda, M.SC., Technical Assistant and Millets Field Collector
Kumari K. N. J. Ayengar, M.SC., Technical Assistant
J. P. Chowdhury, M.SC., Technical Assistant (until December, 1960)
R. N. Kaw, M.SC., Technical Assistant
D. P. Mohan, M.SC., Technical Assistant
G. P. Saxena, M.SC., Technical Assistant

Andhra Pradesh

Shri S. Ramachandra Rao, State Specialist in Millets (Guntur)
Shri S. Vittal Rao, Senior Maize Breeder (Hyderabad)
Shri G. Kameshwar Rao, Farm Superintendent (Hyderabad)

Gujarat

Dr. N. Krishnaswamy, Head, PIRRCOM Center (Surat)
Shri N. P. Wankhede, Agronomist
Shri S. C. Chakravarty, Chemist
Shri V. V. Thobbi, Entomologist
Shri Jagdishwar Nath, Pathologist

Madhya Pradesh

Shri N. Bholanath, Head, PIRRCOM Subcenter (Gwalior)

Madras

Dr. V. Santhanam, Head, PIRRCOM Center (Coimbatore)
Shri R. C. Mandal, Agronomist, PIRRCOM Center (Coimbatore)
Shri B. Appaji Rao, Chemist, PIRRCOM Center (Coimbatore)
Shri Veda Moorthy, Entomologist, PIRRCOM Center (Coimbatore)

Shri N. V. Sundaram, Pathologist, PIRRCOM Center (Coimbatore)
Dr. S. N. Bharadwaj, Physiologist, PIRRCOM Center (Coimbatore)
(Vacant) Millets Breeder, PIRRCOM Center (Coimbatore)
Shri D. Krishnaswamy, Research Assistant, PIRRCOM Center (Coimbatore)

Maharashtra

Dr. V. M. Sahni, Head, PIRRCOM Center (Amravati)
Shri S. S. Verma, Agronomist, PIRRCOM Center (Amravati)
Dr. B. K. Dhar, Chemist, PIRRCOM Center (Amravati)
Dr. M. R. Siddiki, Entomologist, PIRRCOM Center (Amravati)
Dr. R. L. Tripathi, Pathologist, PIRRCOM Center (Amravati)
(Vacant) Physiologist, PIRRCOM Center (Amravati)
Dr. N. G. Prasadarao, Head, PIRRCOM Subcenter (Mohol)

Mysore

Dr. M. N. Sadaphal, Agronomist and Officer In Charge, PIRRCOM Center (Dhadesugur)
Shri S. B. Priyavartharao, Head, PIRRCOM Subcenter (Bellary)
Shri S. R. Kaiwar, Head, PIRRCOM Subcenter (Dharwar)

Rajasthan

Shri B. H. Matai, Head, PIRRCOM Subcenter (Ajmer)

Ganga Hybrid Makka 101 seed being unloaded for drying.

Director's Introduction

The progress of the Indian Agricultural Program during the past year is notable for the attainment of several bench marks.

The direction of the Post Graduate School of the Indian Agricultural Research Institute (IARI) has been assumed by an Indian scientist, and the first students have completed requirements for the award of M.Sc. and Ph.D. degrees in the agricultural sciences. Several new buildings for the Post Graduate School and the research program of the IARI have been finished and others are nearing completion. Another achievement in education during the year has been the development of plans for the establishment, during the Third Five Year Plan, of autonomous agricultural universities which will be responsible for integrated programs of teaching, research, and extension in several states.

Four new maize double-cross hybrids, well adapted to Indian conditions, have been perfected and released by the Coordinated Maize Breeding Scheme during the year. These hybrids possess the capacity to yield at least 50% more than the common local varieties under good conditions of fertilization and management; in addition, they have the flinty grain type preferred by the local cultivators, offer an acceptable tolerance to the more serious diseases and pests, and are produced from vigorous inbred lines that can be grown satisfactorily under local conditions. The local names given these hybrids—Ganga Hybrid Makka 1, Ganga Hybrid Makka 101, Ranjit Hybrid Makka, and Deccan Hybrid Makka—appear to be fortunate choices and are proving popular.

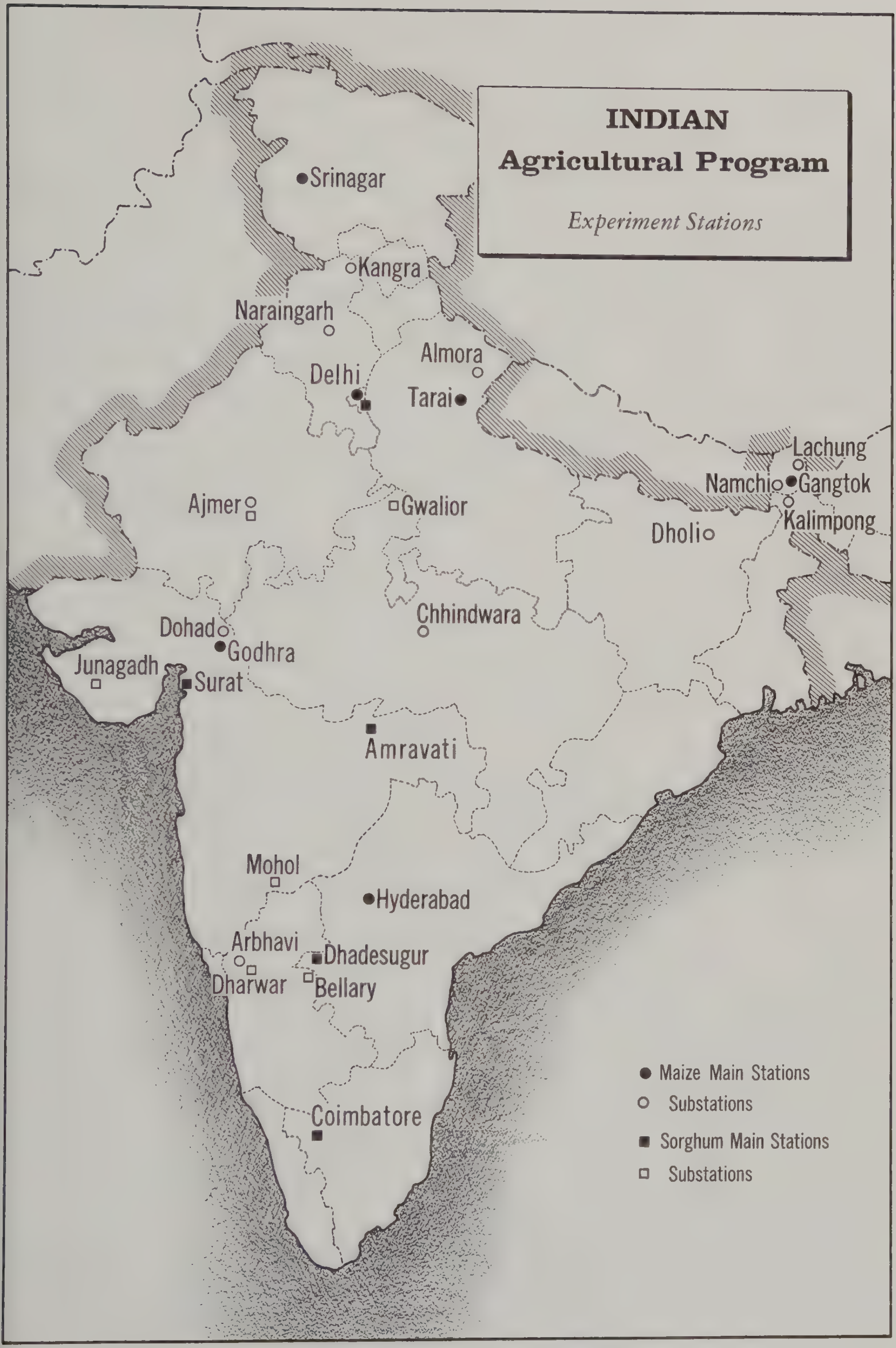
The development of detailed plans for the formation of a Central Seed Corporation, which has been authorized by the government, brings within sight a program of sufficient scope and resources to provide cultivators with adequate quantities of seed of improved maize hybrids and other improved crop seed and to take measures which will assure seed quality control. Pending the formalization of arrangements for the creation of the Central Seed Corporation as a legal entity, extensive interim measures are being undertaken by the Indian Council of Agricultural Research (ICAR), in cooperation with The Rockefeller Foundation, the U. S. Technical Cooperation Mission, and the Ford Foundation, to begin building up seed stocks and developing the necessary facilities and training programs.

Two field teams have continued the systematic collection of indigenous varieties of sorghum and millets, and more than half the important production areas of India have now been covered. It is hoped that this initial survey will be completed in 1961. The project now has a wealth of genetic material from India, Africa, and the United States, and is proceeding with its evaluation and utilization in breeding programs. A substantial number of the more promising sorghum varieties have been crossed with Male Sterile Kafir 60 to produce hybrids for preliminary evaluation. If a vigorous hybrid or hybrids with suitable grain quality can be identified, there is considerable interest in proceeding with production and distribution to cultivators.

Observations made during the year have resulted in the development of a number of techniques for improving and simplifying seed drying and storage methods. The new systems will permit substantial economies and, at the same time, provide for maintenance of good seed quality and germination for reasonable periods of time.

Considerable progress has been made in land development and in the improvement of physical facilities and equipment at several experiment stations connected with the cooperative program.

Most gratifying of all, however, is the presence of the growing group of able and dedicated Indian scientists with whom we are working. The progress of our cooperative efforts will, in the long run, be measured by the productivity and effectiveness of this group and by the extent to which these people are able to serve their country.


INDIAN
Agricultural Program
Experiment Stations
Srinagar
Kangra
Naraingarh
Almora
Delhi
Tarai
Lachung
Namchi
Gangtok
Kalimpong
Ajmer
Gwalior
Dholi
Chhindwara
Dohad
Godhra
Junagadh
Surat
Amravati
Mohol
Hyderabad
Arbhavi
Dhadesugur
Dharwar
Bellary
Coimbatore
● Maize Main Stations
○ Substations
■ Sorghum Main Stations
□ Substations

Cooperating Federal and State Experiment Stations, Indian Agricultural Program.

Station	Size (acres)	Altitude (feet)	Av. temp. (°F.)		Av. rainfall (inches)	Soil types	Principal fields of investigation
			Max.	Min.			
MAIN STATIONS							
Amravati, Maharashtra	400	1,213	116.0	41.0	33.52	Black cotton	Sorghum
Coimbatore, Madras	600	1,400	89.3	69.9	23.23	Red loam	Sorghum
Delhi, Delhi	1,000	750	115.0	31.0	23.22	Alluvial—Silty	Maize; Sorghum
Dhadesugur, Mysore	322	1,161	108.0	53.0	23.75	Sandy loam	Sorghum
Gangtok, Sikkim	6	4,500	77.0	59.0	150.00	Sandy loam	Maize
Godhra, Gujarat	15	447	112.0	43.0	35.00	Sandy loam	Maize
Hyderabad, Andhra Pradesh	120	1,760	108.0	56.0	25.27	Sandy loam—Clay loam	Maize
Srinagar, Jammu and Kashmir	60	5,200	95.0	19.0	25.00	Loam	Maize
Surat, Gujarat	158	19	100.0	58.0	43.00	Black cotton	Sorghum
Tarai, Uttar Pradesh	16,000	800	110.3	31.8	52.45	Loam—Clay loam	Maize
SUBSTATIONS							
Ajmer, Rajasthan	200	1,595	114.0	27.0	25.00	Sandy loam—Loam	Maize; Sorghum
Almora, Uttar Pradesh	12	4,200	104.0	28.4	50.00	Sandy loam—Clay loam	Maize
Arbhavi, Mysore	15	1,920	108.0	55.0	23.00	Sandy—Sandy loam	Maize
Bellary, Mysore	214	1,460	108.0	52.0	20.00	Black cotton	Sorghum
Chhindwara, Madhya Pradesh	6	2,236	115.0	32.0	39.00	Sandy loam—Clay loam	Maize
Dharwar, Mysore	800	2,200	104.0	48.0	30.00	Loam	Sorghum
Dholi, Bihar	240	160	113.0	39.2	45.00	Sandy loam—Loam	Maize
Dohad, Gujarat	6	1,001	115.0	40.0	36.00	Sandy loam—Clay loam	Maize
Gwalior, Madhya Pradesh	120	735	90.6	66.0	29.00	Alluvial	Sorghum
Junagadh, Gujarat	702	200	119.3	41.3	40.00	Loam	Sorghum
Kalimpong, West Bengal	12	3,500	89.0	44.0	91.75	Sandy loam	Maize

Station	Size (acres)	Altitude (feet)	Av. temp. (°F.) Max.	Av. temp. (°F.) Min.	Av. rainfall (inches)	Soil types	Principal fields of investigation
SUBSTATIONS (*Cont.*)							
Kangra, Punjab	9	2,195	103.7	44.2	90.00	Clay loam	Maize
Lachung, Sikkim	—	8,500	—	—	60.00	Sandy loam	Maize
Mohol, Maharashtra	130	1,500	—	—	26.60	Black clay	Sorghum
Namchi, Sikkmim	—	5,000	—	—	80.00	Sandy loam	Maize
Naraingarh, Punjab	400	800	115.0	40.0	18.00	Sandy loam	Maize

Post Graduate Council meeting with new students.

Agricultural Education

In November, 1960, Dr. A. B. Joshi was selected Dean of the Post Graduate School of the IARI, and assumed the duties of that position. He also continued to carry temporarily the responsibilities of his former post of Head of the Botany Division of the IARI, until the appointment of a successor. Up to the time of Dr. Joshi's appointment, the field director of the Indian Agricultural Program served as Acting Dean.

The third entering class was admitted to the Post Graduate School in October, 1960. As in the past, the number of applicants exceeded the openings available by approximately seven times, and competition for admission was keen. Selection was made on the basis of merit as shown by the candidate's previous record and by the qualifications he demonstrated in interview before the combined Post Graduate Council and Institute Council. This procedure has resulted in the selection of a particularly competent body of postgraduate students.

At the end of the second trimester, in April, 1961, a total of 351 postgraduate students was enrolled, 182 candidates for the M.Sc. and 169 candidates for the Ph.D. Forty-eight of these students are junior members of the IARI staff, who take a part-time program of postgraduate work to improve their professional competence and still carry on their duties of employment.

In October, 1960, the first group of students fulfilled requirements for the award of degrees, four students having completed work for the Ph.D. and 78 for the M.Sc.

The faculty of the Post Graduate School now numbers 129, and is comprised of 76 professors and 53 assistant professors.

The newly authorized divisions of Agricultural Economics and Agricultural Extension are slowly taking shape, although recruitment of staff is not yet complete and the divisions must continue to occupy temporary quarters until the building authorized for their use has been constructed.

Work is proceeding rapidly on new buildings at the Institute. An extension of the director's office, which provides new office accommodations for the Post Graduate Dean and his staff, and a new auditorium building with auxiliary seminar rooms have been completed. An extension of the library, a cereal research laboratory, and a building for horticultural research and a fundamental genetics wing are under construction; it is expected that they will be finished during the present calendar year.

At the request of the Government of India, the field director has spent considerable time during the past year working with a committee to advise the states and the central government on plans for the development of agricultural universities during the Third Five Year Plan. The draft legislation and specific proposals of several states have been examined by the committee, the institutions concerned have been visited, and discussions have been held with the appropriate officers and leaders. A set of general principles has been worked out and specific suggestions have been offered.

Provision is being made in the Five Year Plan for central assistance in the development of several universities in the states, to be organized according to the recommendations of the committee. These will be non-affiliating universities with an autonomous board of control and unified management. As a rule, each will include colleges of agriculture, animal science and veterinary medicine, domestic science, and agricultural engineering, as well as a core school of basic sciences and humanities. In addition to teaching, the universities will be responsible for agricultural research and the educational aspects of extension, generally on a statewide basis, and will strive to provide effective coordination of these three activities.

Ganga Hybrid Makka 101 seed at harvest in Hyderabad.

Maize Improvement Scheme

The Coordinated Maize Breeding Scheme, which has been in operation for four years as of March 31, 1961, was originally sanctioned for five years at a total cost to the Indian Council of Agricultural Research (ICAR) of Rs 2,600,000. The expenditure was distributed over 13 maize research stations. In view of the progress made, a five-year extension of the scheme has been sanctioned, at a total cost to ICAR of Rs 4,800,000. The extended scheme takes into account the need for related fields of study in developing a coordinated team approach to maize improvement and includes provision for five additional maize research stations, which will accommodate Sikkim and Himachal Pradesh and Maharashtra states.

From the beginning there has been steady advance in the Coordinated Maize Breeding Scheme. During the period covered by this report, however, a remarkable acceleration in progress has occurred. While this is attributable in part to the continued improvement of facilities and techniques, it is in greater measure the fruition of the work of previous years, which has resulted in development of genetic material to the stage of advanced testing and the release of hybrids.

Personnel and Facilities

The program is operating with much closer to a full complement of staff than in the past. More important, however, is the fact that many of the research people have gained experience in the program and are carrying on very successful work in a spirit of cooperation.

Physical facilities have been greatly improved during the last 12 months, especially in regard to land and to seed storage. The Srinagar station has been relocated on a new 50-acre farm which will not be subject to periodic flooding, as was the previous site. The land is suitable and irrigation water is available. Considerable work has been done in laying out and leveling fields, and in developing a good drainage and irrigation system.

At the Naraingarh station, where a 35-acre block of land is being developed for maize research, irrigation and drainage systems have been worked out and the land has been leveled. Continued effort is being directed at weed control.

A new station in Bihar has been obtained and developmental work will start soon. This station is about 6 miles from Pusa, and will replace the station there.

Most stations are now able to catalogue and store seed stocks properly, and many have cool seed storage rooms, equipped with window air-conditioners and dehumidifiers.

Some stations need more developmental work but, in general, farming and farm management practices at the maize research stations have been greatly improved.

BREEDING PROGRAM

A large program of inbreeding, selection, and topcrossing has been continued in 1960. Many outstanding inbred lines have been identified and have reached the single- or double-cross stage. Consequently, some centers have begun to establish new germ plasm complexes involving Indian and exotic materials in order to initiate a new cycle of breeding.

Research has progressed to the stage at which the highly diverse germ plasm available to the project breeders can be grouped according to adaptation to agro-climatic zones.

The germ plasm of United States origin appears to be best adapted to the submountainous regions of the Himalayas. Fortunately, some Caribbean and Colombian flint types also appear to be well adapted to this zone. Thus, it is possible that both the flint and dent germ plasm complexes can be exploited for future improvement of maize.

In the northwestern plains region, most of the materials that appear best adapted are flint types from the Caribbean area and certain types from South America. Although the Indian open-pollinated varieties do not appear promising *per se*, varietal crosses of Indian × Central or South American material have given excellent performance. Also, a few inbred lines from Indian material combine exceptionally well with diverse material from other parts of the world.

In the northeastern plains region, the same germ plasm complexes appear to be adapted as in the northwestern region. In addition, complexes developed by intervarietal hybridization of North American × Central or South American material present good possibilities as basic breeding material.

Conditions in the peninsular region are very favorable in that materials from Central, South, and North America, as well as from the Caribbean area, are generally well adapted. The combination of environmental factors in this region gives the effect of a neutral climate, in which strains from different latitudes appear to grow as well as in their native habitat. Intervarietal hybrids between these groups of materials tend to exhibit very striking heterosis.

During the past year 12 different single-cross yield trials were grown and predictions of double crosses were made. A total of 106 double crosses, involving 48 inbred lines, has been made on the basis of the predictions for testing in uniform yield trials. In addition, 14 synthetics were made from a number of outstanding inbred lines and will be included in yield trials during kharif (summer), 1961. While the advancement of material to predicted double-cross combination is evidence of striking progress in research during 1960, it must be remembered that this advance is based on the successful work of the preceding three years.

The Indian cultivators' experience with hybrid maize to date has been largely with yellow colored, dent-grained hybrids introduced from the United States. In general, both the cultivator and the consumer prefer maize with orange to orange-yellow flint grain, characteristic of the majority of local or "desi" open-pollinated varieties. Some of the deficiencies of the local varieties are potentially low yielding ability, shallowness of grain,

Male rows in a Ranjit Hybrid Makka seed production field, Hyderabad.

A topcross trial at Hyderabad.

susceptibility to *Helminthosporium* leaf blights, poor husk cover and standability, and, in group terms, a relatively narrow genetic base.

Four double-cross hybrids have been named, released, and recommended to Indian cultivators living in the plains and peninsular areas. These hybrids, the results of the efforts of the staff of the Coordinated Maize Breeding Scheme, possess the characteristics necessary for successful cultivation as well as those desired by the majority of Indian farmers. All have excellent reproducibility, vigor, and pollen formation, good standability and husk cover, and medium ear placement on the stalk. Breeder seed of the inbred lines will be maintained by the appropriate stations on a geographical basis.

One released hybrid, Ganga Hybrid Makka 1, flowers about seven days and matures about ten days earlier than the others. Three of the inbred lines in the pedigree of this hybrid are orange-yellow, flint-grained types that were developed in India; the original selections were made prior to the origin of the Coordinated Maize Breeding Scheme. The fourth inbred line is a yellow, dent-grained type originating in the southern United States. The hybrid possesses the characters to which the Indian cultivator is accustomed and, in addition, has a predicted yield performance of 25% to 60% above the best-yielding "desi" varieties, depending on locality. It is susceptible to *Helminthosporium* leaf blight (*H. turcicum*), but this disease is normally not present in the zone for which it is recommended, the Indo-Gangetic Plain.

Only six inbred lines compose the other three released hybrids. All are flint × dent hybrids. Four of the inbred lines are orange-yellow, flint-grained types of South American origin and two are yellow, dent-grained types of United States origin. The hybrids flower and mature at medium dates, i.e., 60 and 90 to 100 days, respectively. They are resistant or moderately resistant to *Helminthosporium* leaf blight (*H. turcicum*) and downy mildew, and are moderately susceptible to corn borer (*Chilo zonellus*). The areas of adaptation differ.

Ganga Hybrid Makka 101 is recommended for the Indo-Gangetic Plain. It is predicted to yield more than 70% over the best "desi" varieties for this area and has deep, bold kernels of orange-yellow flint type. Ranjit Hybrid Makka, recommended for Western India, has a grain type nearly identical with that of Ganga 101. Its yields are predicted to exceed the best "desi" varieties by about 40% to 120% in this extensive and diverse area. Deccan Hybrid Makka has been recommended for the peninsular region of India, where its yields are predicted to exceed by 75% to 140% the best "desi" varieties. This hybrid has two flint and two dent lines in its pedigree and, as a result, its grain color and type are yellow and nearly flint.

Experience during the 1960-1961 rabi (winter) season in the production of inbred lines and single- and double-cross seed lends confidence in regard to the reproducibility of the seed stocks. A major handicap of previously tested United States hybrids was their deficiency in this respect. For example, the yields of the four inbred lines of Ranjit ranged from 685 to 1,314 lb./acre. In production plots of approximately 1 acre in size grown near Hyderabad, the yields of Ganga 1, Ganga 101, Ranjit, and Deccan were 1,708, 2,000, 2,907, and 2,932 lb./acre of seed, respectively.

YIELD TRIAL RESULTS

The 1960 program of research was the largest in the history of the Coordinated Maize Breeding Scheme. Yield trial data were obtained from topcrosses, single crosses, and experimental double crosses in 14 locations: Srinagar, Kangra, Almora, Kalimpong, Gangtok (Sikkim), Delhi, Ajmer, Naraingarh, Tarai, Pusa, Hyderabad, Arbhavi, Dohad, and Chhindwara. The trials involved 46 different sets of materials in 104 separate tests.

TOPCROSS TRIALS

The number of inbred lines tested in topcross trials was fewer than in 1959, but the trials were planted at a larger number of locations. In addition, the topcrosses were tested on a zonal basis corresponding to the area of adaptation of the respective inbred lines. A total of 30 trials was conducted and certain inbred lines of diverse origin proved outstanding performers. Several lines, especially a number derived from Amarillo de Cuba, appear on the horizon for possible inclusion in future hybrids, although one or two more years of collecting data will be necessary before they reach the single-cross level.

SINGLE-CROSS TRIALS

Twelve single-cross trials were conducted during kharif, 1960, and on the basis of the data obtained 106 double crosses were made during rabi, 1960-1961. These 106 experimental double crosses will be included in uniform yield trials on an all-India basis within the Coordinated Maize Breeding Scheme during kharif, 1961. The parental inbred lines of the single crosses tested at each location were also planted at these locations in an effort to increase breeder seed and to study their agronomic performance. In addition, 14 second generation synthetics, made from many of the outstanding inbred lines, will be tested in uniform yield trials during kharif, 1961. As there is considerable interest in white maize in several areas in India, the first step was taken during rabi, 1960-1961, to develop a few improved white maize materials. An exceptionally high-performing white dent-flint single cross was crossed to ten white varieties. These white double-topcrosses will be tested in uniform yield trials during kharif, 1961.

Certain yellow flint inbred lines from Colombia have proved to be adapted and good performers under Indian conditions. Single crosses made from these lines were crossed to the dent single cross, Kys × C.I. 21E, a superior performer at several locations in India. The resulting 27 double crosses, together with 4 from Colombia, 8 from Almora, 3 from Hyderabad, and 1 from Delhi, were tested in a cooperative yield trial at 11 locations. Yields ranged from non-statistically significant amounts above the high-yielding local variety checks at Almora and Ajmer, to 131% and 175% above the local check varieties at Naraingarh and Tarai, respectively. Nine hybrids gave superior performance in Zone 1 at each of the 3 locations; 18 were superior at each of 2 locations in Zone 2; 37 were outstanding at Tarai, the only station reporting from Zone 3; and in Zone 4, 1 hybrid was superior at each of 3 locations, while 3 were outstanding at 2 locations. Two hybrids were outstanding in all 4 zones of India, 6 in 3 zones, 13 in 2 zones, and 15 at only 1 location.

AGRONOMIC TRIALS

During the 1960 kharif season, two uniform agronomic trials were located at each of four stations: Arbhavi, Naraingarh, Srinagar, and Tarai. The objectives of these preliminary trials were to study the response of maize to fertilizers and to gain information on optimum plant population.

Texas 26, a hybrid, and local recommended varieties responded in yield with up to 80 lb./acre of nitrogen, but gave little or no additional response with applications of 160

The Fifth All-India Maize Breeders' Conference at Hyderabad.

lb./acre. The estimated return from 80 lb./acre of fertilizer nitrogen was 138 rupees for Texas 26 and 36 rupees for the local varieties. Application of 50 lb./acre of both phosphorus (P_2O_5) and potassium (K_2O) resulted in increased yields and economical returns. The hybrid responded more favorably to fertilizers than did the local varieties. No appreciable or consistent yield response could be attributed to an application of trace elements, i.e., magnesium, iron, manganese, boron, copper, zinc, or molybdenum. A plant population of 15,000 to 20,000 per acre appeared best for the hybrids in these trials.

TRAINING PROGRAM

During this third year of the training program in maize breeding and seed production, candidates from Bihar, Sikkim, and Rajasthan participated. Two candidates from Uttar Pradesh returned to complete the portion of the program that they missed during 1959.

As in the past, the program covered all aspects of practical maize breeding and hybrid seed production, from sowing to analysis of data. Among those who lectured on various aspects of maize improvement were: Dr. E. J. Wellhausen, The Rockefeller Foundation; Dr. A. J. Ullstrup, Purdue University; and Dr. L. M. Humphrey, U. S. Technical Cooperation Mission. In addition, each trainee presented a seminar on some topic concerning maize breeding, and the maize personnel of the Delhi center presented seminars on special research projects.

So that the candidates might gain experience in different phases of maize breeding and seed production, each was assigned personal responsibility for a specific part of a research project or of seed production. After he had successfully carried out one job, the trainee was allocated another area of responsibility.

During 1960, Shri M. Sankar Rao of the Hyderabad station and Shri Amir Singh of the Delhi station returned to India after approximately one year of study at the University of Nebraska; Shri K. R. Chopra, Technical Assistant, left India for graduate training at the University of Nebraska.

DISEASES OF MAIZE

During the past year the Coordinated Maize Breeding Scheme received valuable assistance from Dr. A. J. Ullstrup, of Purdue University, who spent approximately four months in India in the course of his project of surveying maize diseases in southern Europe, Africa, the Middle East, and Asia. Dr. Ullstrup visited several stations in the maize scheme and utilized facilities in the Division of Mycology and Plant Pathology at IARI to identify pathogens encountered. Five of the pathogens that he found on maize had not previously been reported as occurring in India or Sikkim:

Pathogen	Disease	Location, State
Diplodia macrospora	Leaf spot	West Bengal and Sikkim
Rhizoctonia zeae	Ear rot	Bihar
Hypochnus sasakir	Leaf spot	Uttar Pradesh
Gleocercospora sorghi	Zonate leaf spot	Sikkim
Gibberella zeae	(Perithecia on old maize stalks)	West Bengal

In addition, Dr. Ullstrup studied and reported on the distribution, prevalence, and severity of other maize diseases occurring in kharif, 1960.

He also made some very valuable suggestions regarding research projects on diseases of maize and, at the suggestion of the coordinators of the maize breeding scheme, prepared a general guide describing some of the important diseases of maize. In view of its utility, this report will be published in the ICAR journal, *Indian Farming*.

First hybrids released for commercial production.

Seed Production

A special committee was appointed in January, 1960, by the Secretary to the Government, Ministry of Food and Agriculture, to develop specific plans to meet the need for efficient production and distribution of improved seeds. The urgency of this need was accentuated by the imminent release of new maize hybrids by the Coordinated Maize Breeding Scheme and, in fact, the project developed by the committee placed emphasis on this crop. Plans were worked out, however, so that production and distribution of improved seeds of all crops could eventually be included.

The committee, which had as one of its members Dr. W. M. Myers, Visiting Professor and Temporary Staff Member of the Indian Agricultural Program, formulated specific, detailed plans for a Central Seed Corporation. This scheme was published as a special report of the Ministry of Food and Agriculture entitled *Improved Agricultural Seeds—With Emphasis on Hybrid Maize*.

At the request of the Ministry of Food and Agriculture, The Rockefeller Foundation agreed to assist further the development of the Central Seed Corporation by making available the services of Professor A. A. Johnson of Cornell University. Professor Johnson has continued to provide technical guidance in the organization and establishment of the Corporation and in obtaining necessary concurrence for plans and operating procedures.

The plan has been approved by the Union Cabinet and by various central and state government bodies, including agricultural officers of state governments. The financial requirements have been included in the Third Five Year Plan and the initial year's budget has been passed by Parliament.

The Central Seed Corporation is being registered under existing legislation (The Indian Companies' Act). The method of financing and the articles and memorandum of association are in the developmental stage and it is anticipated that the company will come into being in the summer of 1961. Meanwhile, ICAR has agreed to underwrite the cost of initial seed stock increase as an interim arrangement, and key Indian officers of ICAR have been working with Foundation personnel during the year in initiating seed production and in planning seed production centers for both foundation and certified seed multiplication. Additional Indian staff have been recruited at the Center and for the foundation seed units, which are to be located in the states.

The main functions of the Central Seed Corporation will be threefold: (1) to undertake on a coordinated, all-India basis the production and distribution of inbred lines and foundation single-cross seed of the hybrids released through the Coordinated Maize Breeding Scheme; (2) by means of financial aid and technical guidance to assist the states in both the public and private sectors to establish and operate certified seed multiplication units for the production of certified double-cross seed of maize and sorghum hybrids, as well as certified seed of other crops that are used in rotation with maize and sorghum; (3) to work toward establishment of adequate quality control measures for seed through an all-India program, by means of training programs and evolvement of state seed certification, seed control, and seed testing measures.

Following the harvest of the 1960 kharif crop, the maize breeders of the Coordinated Maize Breeding Scheme selected four double-cross hybrids for preliminary multiplication during rabi, 1961. Inbreds and single crosses were produced at Pusa, Bihar, and the double crosses at Rajendranagar, near Hyderabad in Andhra Pradesh. The four hybrids, Ganga 1, Ganga 101, Deccan, and Ranjit, were subsequently recommended for release by the 1961 All-India Conference of Maize Breeders, which also recommended pursuit of a vigorous program of seed production. To avoid the loss of a single season in building up the maize hybrid seed supplies before the formation of the Central Seed Corporation, ICAR has given financial support to seed production during 1960-1961.

The 1960 rabi production was very successful and will permit the multiplication during kharif, 1961, of about 50 acres of inbred line and single-cross seed and 150 acres of the double-cross seed. The inbred line and single-cross seed production will be carried on in Uttar Pradesh, the Punjab, and Andhra Pradesh, under the temporary sponsorship of ICAR, which will also coordinate the production of the double-cross seed in five or six states. All new seed production facilities are being organized with a view to developing units of at least 500 acres.

Steps are being taken to work out a seed policy that will guide the working relations among the maize breeders, ICAR, the Central Seed Corporation, and the states in such matters as the handling and release of inbred lines, responsibilities for maintaining breeder seed, and the production and distribution of foundation single-cross seed.

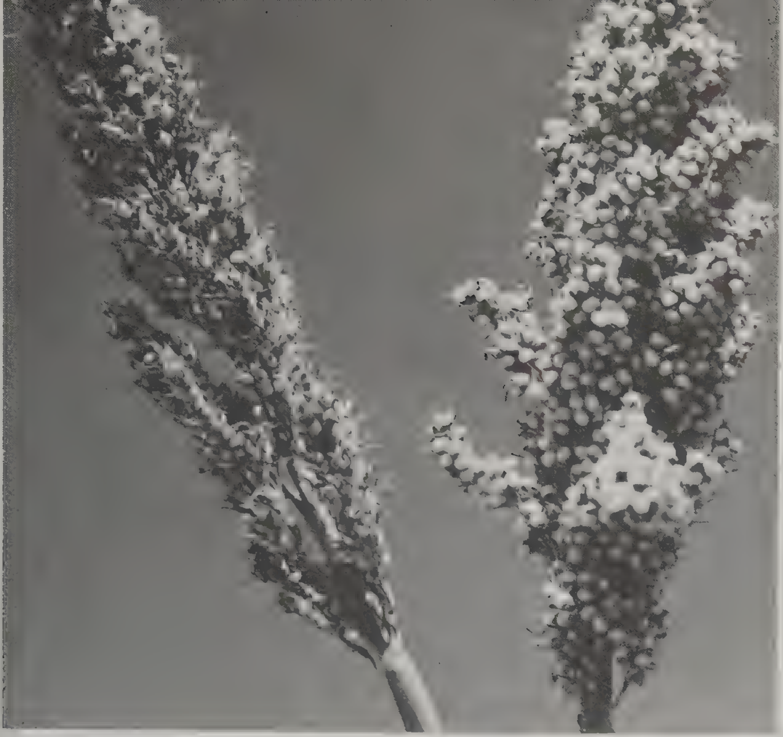
Quality control for seeds of superior varieties and hybrids is presently lacking in India. However, the need for initiating seed certification, seed control legislation, seed testing, and the training of seed specialists is recognized and the plans for the Central Seed Corporation make provision for a program by which the Corporation (ICAR is an interim agency) is to coordinate such activities.

During the year, the Intensive Agricultural Demonstration (Package) Program, conducted under a joint Ford Foundation and Government of India contract, has been initiated in seven districts, one in each of seven states. With respect to the seed program, Rockefeller Foundation personnel have been working with the Package Program staff in training and demonstration work, as well as in the development of an over-all seed quality control plan for superior varieties and hybrids to be used in the Package Districts.

The seed work of The Rockefeller Foundation in the Package Districts will be done in close cooperation with the Central Seed Corporation. While hybrid maize and hybrid sorghum will be important in only three or four of the seven Package Districts, the training plans for quality control developed under Center leadership will be applicable to every area of India, including all Package Districts.

During the past year, the Foundation has equipped a seed testing laboratory at IARI, which is to serve as a training center for personnel who will staff the state seed testing laboratories. The laboratory will also enable IARI to pursue seed testing research leading to establishment of seed certification standards and seed labeling requirements in seed control.

The Foundation will continue to provide technical assistance for seed production and it is expected that during the next year temporary staff members will be working in India on problems connected with the production of foundation seed and installations for processing and storing the seed.



Midge attack prevented seed development on the left earhead.

Sorghum—Millet Improvement

Sorghum, the most widely grown dryland food grain crop in India, is cultivated on about 40 million acres. The approximately 8.5 million tons of grain produced annually are used almost exclusively for direct human consumption. Sorghum is grown for both its grain and fodder except in the northern Punjab and Rajasthan areas, where it is used primarily as a fodder crop.

The 1960-1961 season proved generally favorable for participant breeding programs at IARI, Delhi; Ajmer and Kotah, Rajasthan; and Hyderabad, Andhra Pradesh. Many new hybrids were observed and the first cooperative hybrid trials were conducted. Numerous new collections from India, Africa, and the United States were evaluated for the first time and some very promising materials have been selected. Collection of millets and maize varieties in India was completed in major millets-growing areas of the country. Extensive cooperative varietal tests were planted at many experiment stations, and tests were also conducted to evaluate the effectiveness of different insecticides and herbicides.

PLANT IMPROVEMENT

UNIFORM TESTING

Uniform yield trials were conducted at 32 experiment stations. Separate trials of sorghum varieties and hybrids were prepared and distributed to the stations as shown in Table 1.

In all trials of varieties the entries were from India or the United States. The three hybrid trials contained varieties from India, Africa, and the United States all crossed to the common female parent, Male Sterile (M. S.) Combine Kafir 60.

From these trials, 11 promising Indian varieties and 4 promising hybrids and varieties have been obtained. Some of the selections appear to have a wide range of adaptation, a matter of importance to seed production and seed quality regulation programs. Most of the yield trial results have been organized into a

TABLE 1.

Trials of sorghum varieties and hybrids, 1960-1961.

Trial name	No. varieties included	No. trials distributed
Exotic grain varieties	14	9
Short season kharif varieties[a]	14	17
Long season kharif varieties	20	16
Fodder varieties	15	12
Advanced hybrid trials	49	4
Preliminary hybrid trials-A	25	7
Preliminary hybrid trials-B	25	5
Rabi varieties[a]	25	4

[a] Kharif season = July to October; rabi season = October to February.

report which has been distributed to cooperators in India and to interested persons elsewhere.

Uniform hybrid trials were organized this year for the first time. Because of the difficulty in obtaining enough seed, the number of trials was necessarily limited. Eighteen of the hybrids tested appear promising; 11 are composed of Indian varieties plus 9 varieties from the United States all crossed to M. S. Kafir 60.

Uniform variety and hybrid trials in several locations were adversely affected by such problems as stalk borers, head insects, the parasitic plant *Striga* (witchweed), birds, diseases, drought, and flooding. Grain yields in the more successful trials generally ranged between 2,000 and 3,000 lb./acre, while fodder yields averaged about 5 tons of air-dried stover per acre.

DEVELOPMENT OF HYBRIDS

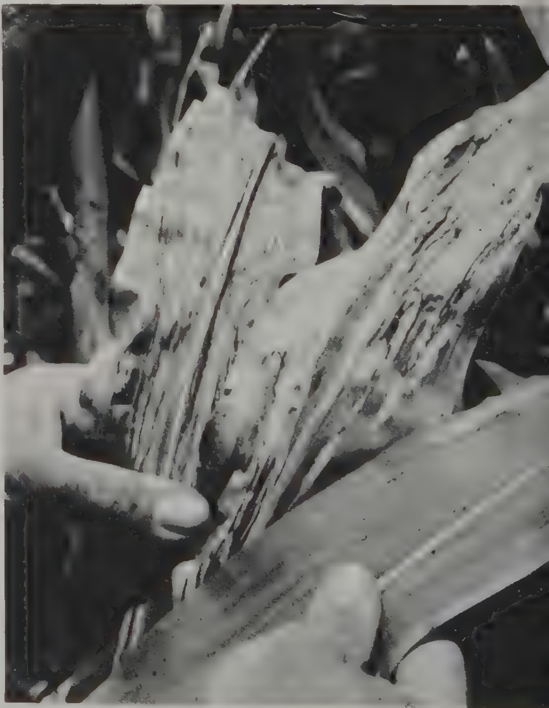
At the end of the 1960 rabi season, 704 hybrids had been observed at Delhi and Hyderabad for the purpose of selecting materials for yield trials. Of these hybrids, 364 were grown for the first time in 1960. Important notes from most of these observations will appear as a special report during the summer of 1961. At Hyderabad, during rabi, 40 hybrids were selected for trials in the 1961 rabi season; at Delhi, 72 hybrids were selected for further breeding and testing.

During the 1960 season, 521 varieties were crossed to M. S. Kafir 60 at Ajmer, Delhi, and Hyderabad.

Results indicate that hybrids can be selected which will substantially outyield either parent and the locally grown varieties. Several isolation plots were planted at Chandigarh and Tarai State Farm during the kharif season and at Hyderabad during the rabi season to increase seed supplies for large plot testing; seed of six hybrids has been obtained.

A major problem associated with the development of hybrids is male sterility. Many hybrids were fertile during the kharif season at Delhi, but sterile during the rabi season at Hyderabad. These preliminary results suggest that a hybrid which is fertile in the rabi

Helminthosporium was severe on susceptible sorghum varieties at Hyderabad during rabi.



season may always be fertile, while a hybrid fertile in the kharif season may become sterile under conditions similar to those of the rabi season. Male-sterile single crosses are being crossed to evaluate the possibility of three-way hybrids.

Grain quality is another problem connected with hybrid development. Some Indian and other potentially desirable pollen-restorers carry complementary factors for dark grain color which, in combination with a similar genetic factor in Kafir 60, produce hybrids with darker colored grain than either parent. This is particularly true of the yellow-seeded varieties and the long panicle branched head types such as the shallus. Fortunately, some of the best grain types are rabi varieties that produce fertile hybrids with good grain quality.

The exotic M. S. Kafir 60 has been used thus far as the common female parent in the experimental hybrid program for several reasons. Its seed is readily available and white in color; it is resistant to lodging and double-dwarf, so that pollination by the usually taller pollen parents is facilitated; it is relatively early (65-70 days to flower) and quite insensitive to day length; it performs well at high populations; it is not highly susceptible to any of the prevalent diseases or insect pests; it has juicy and partially sweet stalks, with the plant remaining green until seed maturity, which enhances its value as a forage crop.

One of the problems in connection with M. S. Kafir 60 is that seed quality of the hybrid is frequently inferior to that of the male parent variety. In order to obviate this limitation, attention is being given to the incorporation of cytoplasmic male sterility into other varieties which are agronomically comparable to M. S. Kafir 60. Several steriles are in the second or later backcross stages of development.

A limited hand-crossing program has also been started to develop superior varieties from the promising local and exotic strains. Sixty-one hand-emasculated crosses produced at Delhi in 1960 are being grown in the F_1 stage at Coimbatore this summer.

Collecting sorghum earheads in a village in Maharashtra.

Collection of Millets

The Rockefeller Foundation is participating in a country-wide program of collecting millets (sorghums, pearl millets, finger millets, and other minor millets). During the second season of collecting, completed on April 1, 1961, two units covered districts in the states of Punjab, Gujarat, Maharashtra, Andhra Pradesh, Orissa, Madras, Kerala, and Mysore. These areas include the major millets-growing tracts of India.

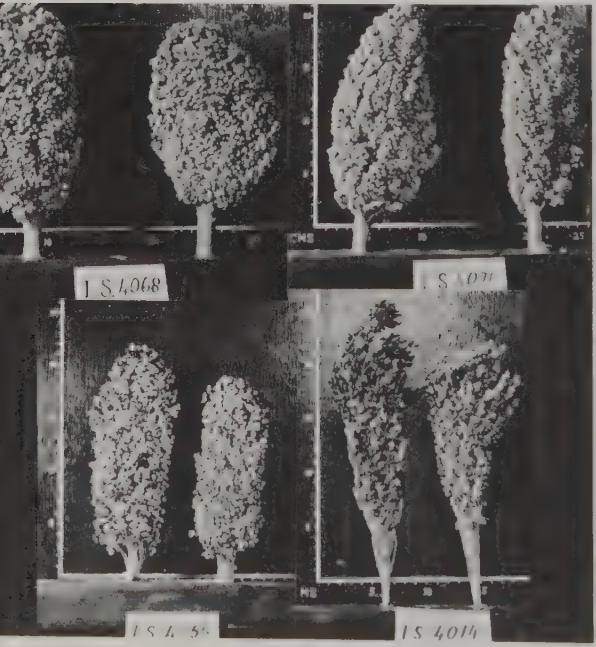
The 2,215 samples collected during the 1960-1961 season bring the total to 3,331. The crop distribution of these samples is: sorghums, 1,703; pearl millets, 462; maize, 352; and small millets, 814. Still to be collected are varieties from Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Bihar, West Bengal, and parts of the Punjab, Madhya Pradesh, and Orissa. It is estimated that the two field collecting units will complete the work in one more season.

A considerable amount of valuable and interesting information has been accumulated by the collectors concerning the purpose for which certain varieties are grown, methods of food preparation from these cereals, cultural practices, and specific agronomic characteristics of locally grown strains. Special agronomic characteristics claimed for particular varieties in the areas of collection include resistance to such hazards as flooding, insect attack, diseases, and drought. Specific types are grown in particular localities for everyday consumption, primarily as unleavened bread, gruel, or cooked like rice. Other varieties that have a sweet endosperm are prized for special purposes: popping, parching, and the making of sweet preparations and scented strains that produce a pleasant aroma when cooked. Certain varieties reportedly produce a dough that has elasticity or would rise if fermented.

EVALUATION OF GERM PLASM

A large proportion of the collection of local and exotic sorghum germ plasm was successfully grown and observed for the first time at Hyderabad during the 1960-1961 rabi season. The planting consisted of 2,514 separate cultures, including 715 lines collected in 1959-1960 from Rajasthan, western Madhya Pradesh, and south-central Maharashtra. A great many promising materials were observed.

Sorghum varieties collected in Rajasthan.



Although the Indian collections exhibited considerable variation in grain, a high proportion had large, pearly grains of excellent quality. The varieties collected from Rajasthan and Madhya Pradesh exhibited less variability than exotic varieties or those from some other sorghum-growing areas in India. Some of the more recently received American experimentals, i.e., yellow or white seeded Hegaris, Feteritas, and Kafirs, have been selected for subsequent evaluation in test crosses. Also interesting and potentially important are the African materials, of which some were collected in Africa in 1959, others obtained from the U. S. Bureau of Plant Introduction, and some received through the United Nations Food and Agriculture Organization in Rome.

A very broad range of plant and head types and growth habit was observed in this material. Among the more interesting agronomic characteristics noted were rapid and luxuriant growth, exceptionally large grains, very good seed quality, high grain yields in certain Hegari types, long earheads (25-40 cm.), and potential bird resistance because of bitter seeds, seeds covered by exceptionally long glumes, or seeds borne in clusters at the ends of flexible panicle branches.

The great range of genetic variability that exists in the sorghums indicates a tremendous potential for improvement and for the development of new and special purposes for this crop. It appears that materials from each of the important growing regions of the world will contribute to the process of improvement. The United States offers highly specialized types developed to give maximum grain yields in the shortest possible time, and Indian stocks include some of the finest grain types for several different purposes. Africa offers probably the richest source of genetic stocks in over-all plant variability.

AGRONOMIC STUDIES

Crop management studies have been carried out during 1960-1961 in cooperation with the Agronomy Division of IARI, the state of Rajasthan (Botany and Agronomy Sections), and at Hyderabad.

Fertility × spacing tests at Delhi indicate that local varieties are less responsive to fertilization and have less capacity for high grain yield than some exotic hybrids.

Weed control, difficult under the best conditions, presents especially severe problems during the humid monsoon period, when rain may occur for days at a time, favoring rapid weed growth while preventing mechanical or hand methods of control. Effective pre-emergence herbicides would be particularly useful under these conditions. Although damage to sorghum and millets crops by herbicides has been unacceptably high in experiments conducted this year, some of the newer herbicides in the triazine group appeared promising in trials at Delhi and Hyderabad during the past season. Included in these trials were 2,4-D, Eptam, Propazine, and Atrazine. Propazine has the advantages of low phytotoxicity for sorghums and pearl millets and general effectiveness against both grassy and broad-leaf weeds, but it appears to give no control of nutgrass, a most persistent and serious pest during the early period of crop development. The effect of Propazine and other triazines on following crops under Indian conditions is yet to be investigated. The older herbicide 2,4-D, which is harmful to sorghums when used as a pre-emergence application, has been reported effective against nutgrass after the weed has emerged. The possibility of combining pre-emergence applications of triazine with post-emergence applications of 2,4-D will be explored during the coming season.

ENTOMOLOGICAL STUDIES

Probably the greatest factor in the reduction and limitation of sorghum production is insect pests, chief among them being shoot flies (*Atherigonia indica*) and the stem borer (*Chilo* and *Sesamia* spp.). Of less importance are mites (*Oligonyclus* sp.) and earhead bugs (*Calocoris* sp.).

Effective control measures against these pests have not been developed. Cultural controls appear relatively impractical owing to the common practice of storing fodder, in which the borer hibernates, and to the widespread presence of alternate hosts.

Interest has increased in developing a program of chemical treatments that will conserve the beneficial predators present and permit the inclusion of biological control operations. Since, however, insect-resistant varieties possess an inherent ability to produce better crops of good quality than susceptible varieties under the same insect population pressure, resistant varieties would seem to offer a more practical solution under local circumstances.

Seed storage room, New Delhi.

Experiment Station Operations

LAND SHAPING AND SOIL PREPARATION

In addition to the general emphasis on land improvement during the past year, three stations have received special attention. At the Naraingarh maize substation in the Punjab, a 35-acre tract has been graded and smoothed, and irrigation channels, roads, and an adequate drainage system have been developed.

At Srinagar, Kashmir, the maize scheme operation has been relocated on a 50-acre tract and the station's tractors and other agricultural machinery have been moved to the site and put into operation. About half the area has been improved and leveled for this season's crop, and improvements for the entrance road and the lining of the main irrigation canal are planned. Since this site for the research work is considered temporary, installations such as a workshop and processing facilities are not planned for the time being. Under the present arrangement, however, considerable difficulty is encountered in the maintenance and repair of equipment.

At Tarai, Uttar Pradesh, where the maize scheme is being integrated with the new U. P. Rural University Experiment Station, it has been necessary to change locations and develop a new 60-acre tract of land within the station for the research program. In addition, considerable assistance is being given to the Rural University in the development of the 500-acre station: land surveys have been made; field topographic maps have been drawn up for land shaping purposes; and lists of recommended equipment with specifications have been prepared. Several conferences have been held with the Dean of the College of Agriculture and other persons regarding the steps to be taken in the initial development and operation of the experiment station farm. It is hoped that similarly integrated stations will be established at other locations, both to develop facilities for the Foundation's cooperative research program and to give assistance in strengthening the over-all institution.

At the three stations that have been mentioned, station layout maps are being drawn up and a field numbering system established. Maps for all of the other stations will be improved during this year, and the use of field history record sheets will be encouraged.

The tile drainage system installed last year at IARI as a cooperative research project is proving very successful and has aroused considerable interest in subsurface drainage. A progress report has been written and an article is to appear in *Indian Farming*. In addition to a significant lowering of the water table in the 15-acre tile-drained area, the effect of adequate drainage plus the application of gypsum is clearly evident in decreasing soil pH, total soluble salts, and exchangeable sodium. This year, in cooperation with the Agronomy Division, detailed crop growth studies are planned to provide more precise information on crop yields in relation to water table levels, adequacy of the drain tile spacing, and distribution and influence of saline and alkaline patches in the area. It is also planned to test the suitability of other materials more economical than clay tiles. If recommended steps are taken to improve the main water outlet for the farm, it is hoped that additional acreages at IARI can be tile-drained in the near future.

SEED PROCESSING AND STORAGE

Several experiments are being carried out to gather general data on seed processing and to solve specific drying and storage problems in the cooperative research programs. At three locations, results of drying seed with forced natural air were very favorable. In December, 1960, at IARI, 200 bushels of ear maize were dried from 18.4% grain moisture content to 10.8% in 40 hours; the blower was operated only during periods when the relative humidity was below 60% and the drying was completed in three days. In another experiment at IARI, records were kept on natural drying of ear maize in an upright wire-mesh bin. The bin was filled on October 20, 1960, with ear maize at 21.1% moisture. After two weeks the moisture content was reduced to 13.3% and on December 9, when the bin was emptied, the moisture content was 10.7%. Germination at the end of storage was 98.0%, and only slight damage from mold and insect attacks was observed.

In line with these experiments, a research project, "Investigation of Economical Grain Drying Methods in India," has been initiated. Further studies will be made next year on the use of natural drying methods, forced natural air, and solar energy. As additional information is obtained, it will be applied to experiment station seed drying, and systems will be recommended for government seed farms and other seed production units.

The safe storage of seed stocks for the cooperative research programs continues to require special study and emphasis. At present, the seed storage rooms at most research stations are equipped with air-conditioners and dehumidifiers that keep temperatures at 70°F. and relative humidity at about 50%. In October, 1960, a research project was begun on the preservation of maize and sorghum seed under tropical conditions. Seeds of both local and exotic varieties, including the four new maize hybrids introduced this year, were included in the experiment. Emphasis is being placed on the storage of seed in sealed polyethylene film bags at various moisture levels under both natural and controlled climatic conditions. Since the standard water vapor transmission rates are known for these polyethylene bags, experimental results can be directly applied to seed storage in containers of other materials by comparison of the relative rates.

Germination tests were made on 21 maize varieties that have been stored for three and one-half years in paper bags at IARI in an insulated room equipped with an air-conditioner and dehumidifier. Average germination of the 9 exotic varieties in the group was 59.0%, and of the 12 Indian varieties, 80.3%. Although the conditions of storage were not adequately controlled and the seeds were in paper bags, results indicate that with the use of resistant containers, this method may be satisfactory for medium long-term storage.

At the Amberpet station in Hyderabad,

Andhra Pradesh, the crop drying blower was operated for seed drying this year without artificial heat. A crop drying fan with portable gasoline engine was installed at Pusa, Bihar, in a small drying room and used on the maize crop with forced natural air. Since the processing building for the maize substation at Tabiji Farm, Ajmer, Rajasthan, is nearing completion, the processing equipment for the research programs there will be installed in the near future. Next year, assistance will be given in completing the seed processing facilities at Tarai, Naraingarh, and Srinagar for use in foundation seed production programs.

MACHINERY USE AND MAINTENANCE

Because of continuing problems in the operation and maintenance of complex, imported machinery, the use of simpler machines is being encouraged. This year, for example, two sets of Indian-manufactured tractors and farm implements are being purchased for maize substations. Similar sets will be provided as the imported items now in use require replacement and as the need arises in the sorghum scheme. The advantages of using Indian-made machinery include local availability of repair service and spare parts, provision by the manufacturer of free operator-training schools, delivery of implements to the station, and assistance from the local distributor in setting up, plus six months' free service.

Literature, prices, and relevant information on available farm machinery and agricultural research equipment have been gathered in India and from other countries. Before vehicles, tools, or equipment are requisitioned,

Testing a single bullock harness.

consideration is given to as many local problems and pertinent factors as possible.

GENERAL SERVICES AND ACTIVITIES

In addition to research projects and experiment station operations work, a number of general services and other activities are performed. A storeroom of supplies, spare parts, tools, and extra equipment is maintained at IARI. Annual inventories are prepared of all items supplied by the Foundation to the divisions of IARI and other research stations. Responsibility is assumed for the maintenance of central office and staff vehicles, air-conditioners, and laboratory and other equipment. Some technical advice has been given on equipment specifications and on the developmental plans of the Central Seed Corporation. Two papers were presented and other efforts have been made to stimulate interest in research work in agricultural processing and crop preservation. To assist in providing these services and to help in experiment station operations, an agricultural engineer holding the M.S. degree was employed in November, 1960.

The Indian Society of Agricultural Engineers held its organizational meeting, and a symposium, in October, 1960, in Kharagpur. Since agricultural engineering as a profession is not widely recognized in India, and since training, research, and other activities in this field have lagged, the organization of this professional society is a highly significant step. Considerable assistance and guidance are being given in its development, in an effort to build the profession and to gain recognition for qualified agricultural engineers, so that they can be more effective in bringing about the many technological improvements needed in Indian agriculture.

Inter-American Food Crop Improvement Program

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Introduction

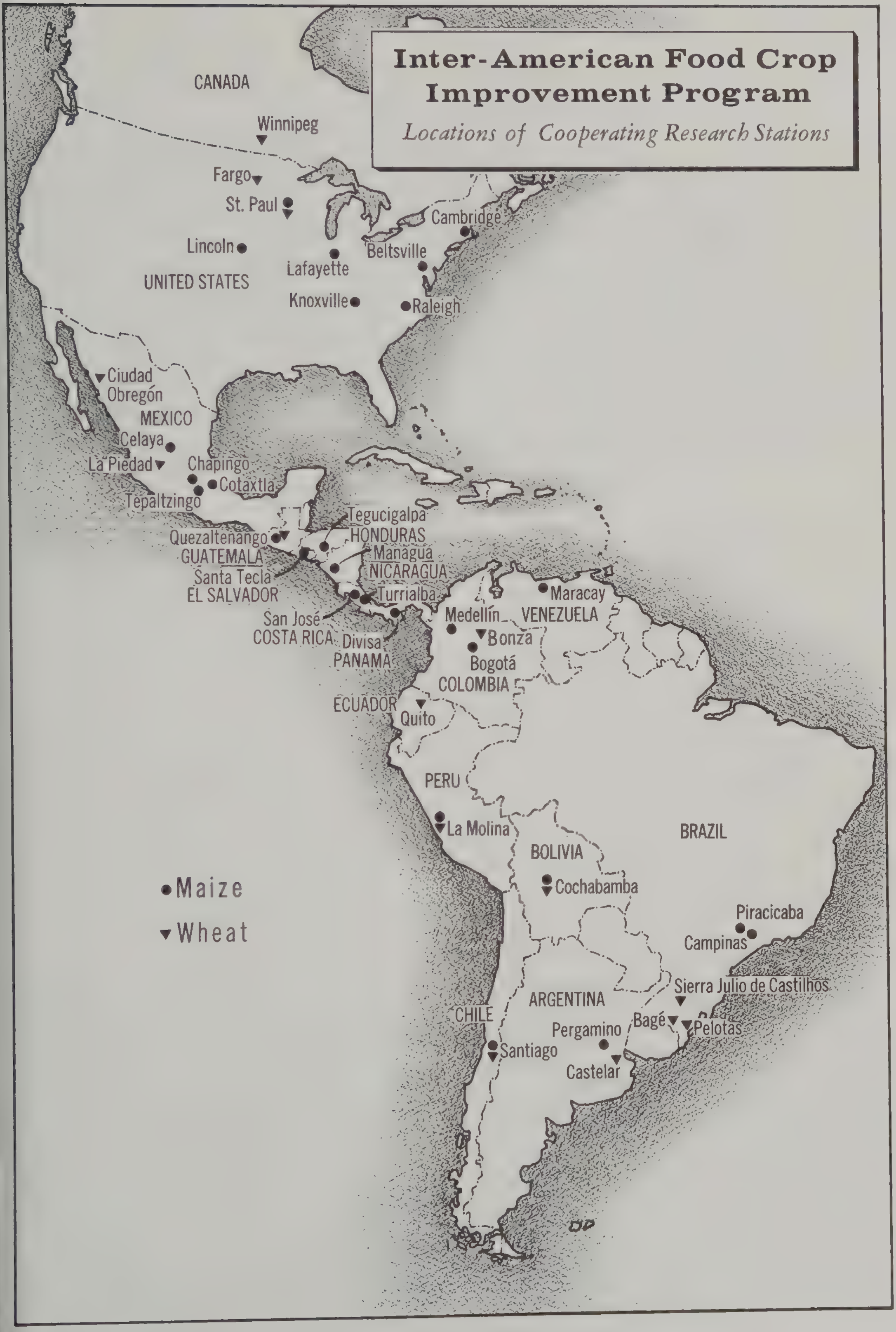
The Inter-American Food Crop Improvement Program now consists of three main projects, each dedicated to one of the important food plants of the Western Hemisphere—maize, wheat, and the potato.

The recently inaugurated program rests on the experience gained through 18 years of cooperative crop improvement work in Mexico, Colombia, and Chile. The inter-American program has grown naturally from the programs in these three countries; each project represents a logical extension from the international exchange of materials and information already begun by the three programs, and from the international character of The Rockefeller Foundation's scholarship and fellowship training awards. While the dates of the formal establishment of the three projects appear quite recent, each is the product of an evolutionary series of informal international cooperative efforts.

The hemisphere-wide maize improvement project, formally begun in 1959, now collaborates with scientists and research centers in 15 American countries, including the United States. One of its principal missions is to analyze the wealth of maize germ plasm collected and identified in Latin America, and to work out simpler and more effective breeding methods for its fullest exploitation in improving maize varieties for widespread use. The training of urgently needed maize specialists is also a goal to which much effort is devoted.

The wheat improvement project, launched in 1960, grew out of the cooperative wheat improvement work in Mexico. Its first formal venture was a collaborative uniform yield nursery now in its second year, which has already shown very promising results from its first distribution. The training awards for the development of wheat specialists include not only young scientists from the Americas but also, in collaboration with the Food and Agriculture Organization of the United Nations, a number from countries in the Middle East.

The potato improvement project began operation early in 1961. Latin America is the home of the potato, and in this region there are wild species, and special environments for the evaluation of disease resistance in domesticated varieties, of which the fullest advantage should be taken in the improvement of this globally important crop. The new project is dedicated to this objective.



Inter-American Food Crop Improvement Program

Locations of Cooperating Research Stations

Corn plot, Central American cooperative program, Choluteca, Honduras.

Maize

Maize is the most important basic food and feed crop in the Western Hemisphere. The possibilities for its further improvement in the Americas as a whole, and especially in Latin America, are exceedingly great. However, if progress is to be accelerated, much more basic research is needed, and maize specialists in the fields of genetics, plant breeding, soil science, entomology, plant pathology, and extension must be trained and given opportunities to apply their knowledge.

The vast range of excellent germ plasm collected and identified in Latin America should be more thoroughly studied, to maximize its efficient and effective use. More information is needed on the relationship, genetic constitution, and types of gene action in the different germ plasm complexes. The nature of the tremendous heterosis exhibited in crosses between certain races must be determined. More must be known about how to blend different races to form new foundation breeding material for the further improvement of varieties in all ecologically different areas. Simpler and more effective breeding methods must be devised in the improvement of open-pollinated varieties for ready multiplication and distribution in underdeveloped areas.

Much of this research can best be done, and some of it can only be done, in Latin America. It can most efficiently be done in combination with a training program planned to alleviate the tremendous dearth of plant scientists in Latin America. For this and other reasons, it is most gratifying to note the growing strength of research and teaching at the Graduate School at Chapingo, Mexico. This institution seems well on its way to becoming a local, regional, and inter-American center of great importance.

The Central American Cooperative Maize Improvement Program has continued to progress in a most satisfactory way. During the year under review, the regional program in the Andean Zone of South America was advanced by several steps. Both Venezuela and Ecuador, like Colombia, depend largely on maize as a basic food, and the governments of these countries are anxious to initiate sound programs leading to further improvement in the production of this crop.

The director of the inter-American maize project spent four months in southern Europe, India, and southeast Asia, getting acquainted with a number of breeding programs and studying the nature and origin of the different kinds of maize germ plasm found in these areas. He also participated in the symposium on Quantitative Genetics and Plant Breeding held at North Carolina State College March 20–30, 1961.

Further attention was given to the identification and classification of the varieties of maize in the germ plasm bank in Mexico. Requests for seed this past year were again numerous; seed has now been sent to almost all parts of the world. According to the reports received, varieties of Tuxpeño from Mexico and the dents and flints of the West Indies have been most outstanding in their performance and often have been directly usable in certain areas at low altitudes in the tropical belt around the world. At the higher altitudes, Eto from Colombia and varieties of the race Comiteco from southern Mexico and Guatemala have been most promising, especially in Kenya, Africa. Experiments for the evaluation of certain kinds of germ plasm on an international basis have been initiated. Cooperative research and advanced training programs were initiated with North Carolina State College, Purdue University, and the University of Nebraska.

More detail on the various activities in which the project was engaged during the past year, and a summary of the important advancements attained, follow.

GRADUATE TRAINING AND RESEARCH AT CHAPINGO

At the Graduate School at Chapingo, various research projects have been initiated in order to give graduate students, through direct participation in fundamental research, a better knowledge of the current principles of qualitative and quantitative inheritance and breeding methods for the improvement of maize.

At present, 12 graduate students are conducting research on certain problems of local and international importance. Eight students in agronomy and genetics and one in entomology are working on thesis problems for the Master of Science degree. Four in agronomy and genetics are working on problems which they hope to use as thesis studies in partial fulfillment of requirements for a Ph.D. degree at different universities in the United States. These theses are in various stages of completion.

The research in which these graduate students are participating is all part of a broader long-range program, centered in Mexico in collaboration with the Graduate School, the National Corn Commission, and the National Institute of Agricultural Research of the Mexican Ministry of Agriculture, and including also certain graduate training centers and experiment stations in the United States and Central and South America. Studies at present involve mainly the identification, origin, and relationships of varieties and races of maize in the germ plasm bank in Mexico; the isolation and evaluation of superior germ plasm; genetic variance and quantitative gene action; and evaluation of special breeding methods.

The program has been very fortunate in having the part-time assistance of various professors and research workers at North Carolina State College, Cornell University, Purdue University, and the University of Nebraska in the planning and direction of the various research studies.

RESULTS OF RESEARCH

(1) Identification of varieties in the Mexican germ plasm bank and formation, description, and preservation of germ plasm pools.

The objectives of this project are threefold: (a) to reduce the number of entities in the bank so that the basic germ plasm may be maintained without exorbitant costs and effort; (b) to form and identify various interbreeding populations which can be used as a main base in new improvement programs or as source of new and additional genes for already highly improved varieties; (c) to form and describe various types of populations useful in the study of the nature of heterosis and quantitative inheritance.

Last year the work was concentrated mainly on the samples collected in Mexico during the last 18 years, which total about 3,500. On the basis of field notes and observations, samples that appeared to be of the same variety were composited. At the same time, from one to three of the samples that went into the formation of a particular composite were earmarked for separate maintenance. In this way the Mexican collection to date has been reduced to approximately 400 varietal composites and 750 individual samples to be maintained separately.

Seed of about 300 of these composites and 600 of the samples to be maintained separately has now been multiplied. The goal is to store 15 kg. of new seed of each of the composites and 2 to 3 kg. of each of the individual samples in the new seed bank established at Chapingo. This new bank, now in operation, is patterned after the facilities established by the U. S. Department of Agriculture at Fort Collins, Colorado. It is equipped to maintain temperature around 0° Centigrade and relative humidity from 35% to 40%.

After the harvest of the 1960–1961 crop is completed at the winter breeding nursery at Tepaltzingo, Morelos, there will be a substantial amount of new seed of most of the composites and individual samples of varieties adapted to altitudes below 6,000 feet in Mexico, although the goal of 15 kg. for the composites and 2 to 3 kg. for the individual samples will not have been reached in all cases. Some will be planted again in the near future for further increase. Composites and individual samples of high altitude varieties are being multiplied at Chapingo in the 1961 growing season.

About 1,000 samples from Guatemala are in the Mexican corn bank. The same procedures for reducing these numbers are being used as with the Mexican material. Many of the late Guatemalan varieties collected at the high altitudes are, however, difficult to propagate in Mexico. Also, the high altitude material is extremely variable, each collection being slightly different from the others. Nevertheless, the collections have been tentatively divided into 150 groups with about 300 samples earmarked for separate maintenance. The entire collection is being planted in Guatemala this year for the purpose of checking these groups.

The classification of the 750 samples from El Salvador, Honduras, Nicaragua, Costa Rica, and Panama is now complete. For this area the collections have been divided into 117 groups and seed of collections in each group has been composited. The number of composites made for each country are as follows: El Salvador, 12; Honduras, 18; Nicaragua, 14; Costa Rica, 49; and Panama, 24. All of these composites (except the high altitude varieties of Costa Rica and Panama) have been multiplied through sib pollination and from 2 to 10 kg. of new seed of each are stored in the new bank. Most of these will be planted again as soon as possible to bring the seed supplies up to 10 to 15 kg. of each. In addition to the 117 composites, 165 collections were propagated individually and from 2 to 3 kg. of new seed of all, except the high altitude varieties, are now available.

So far, no composites have been made from the 295 samples collected from the Caribbean in the fall of 1959. These are still under study.

Once the "varietal composites" are completed for all regions, the second step will be to combine them into racial composites, perhaps on the basis of three maturity classes within each race, through a system of pyramidal crosses.

(2) Evaluation of varieties in Mexico for general combining ability.

In the study and classification of the material in the germ plasm bank, as many as 200 different varieties of the race Tuxpeño were identified. Varieties of this race are very widely distributed in the lowlands of Mexico, as one might expect from their superior yielding ability and generally good agronomic characters. They are the predominating varieties in the lowlands of northern Mexico, and along the Gulf Coast up to 1,000 meters inland. They are also prevalent along the Pacific Coast as far north as the State of Jalisco. The varieties vary greatly in maturity, height of ear, size of ear, grain type, and in many other characters. In order to get some idea of the variation in general combining ability among them, all varieties have been crossed with a variety of the race Pepitilla. Seed from these crosses is now planted in yield tests. The same group of varieties, as soon as the work can be done, will be tested in combination with a variety of each of the races Tuxpeño, Celaya, Cónico Salvadoreño, Cuban flint, and a corn belt composite.

(3) Evaluation of material in the Mexican corn bank for specific characters.

Pulp-fiber evaluation studies have been initiated in a small way in collaboration with North Carolina State College. Also, studies are being made on stalk strength and rind thickness in the different varieties in the bank in collaboration with North Carolina State College and the Agricultural Research Service of the U. S. Department of Agriculture.

Studies on protein quality of the different races are being initiated with Purdue University.

(4) Distribution of the gametophyte factors Ga/ga in Mexico.

A number of varieties of each race are being tested for the Ga/ga factors which affect the cross-fertility relationships among different varieties of maize. A preliminary survey has now been completed, but some of the work will need to be repeated before any special conclusions can be drawn. This work is being carried on in collaboration with Dr. O. E. Nelson at Purdue University.

(5) Heterosis in inter- vs. intra-racial crosses.

All possible crosses have been completed among 25 Mexican races of maize. Seed of these crosses is now being prepared for testing at high, low, and intermediate altitudes. All possible crosses among 12 selected varieties within the race Tuxpeño are now being tested to determine how heterosis of intra-racial crosses compares with that of interracial crosses. A similar study, also ready for final tests, involves varieties and races of Central America.

Two years' data have been accumulated in an experiment involving Mexican races crossed to three different testers (Tuxpeño, Vandeño, and Iowa Stiff Stalk synthetic), including the F_1 and F_2 comparison. Preliminary analyses indicate that one tester is as good as another in rating relative combining ability among races. In the F_1 by F_2 comparison, the F_2 yielded approximately 75% of the F_1, close to the midpoint yield of the parents involved.

(6) Nature and magnitude of genetic variability within varieties and races.

Several North Carolina Design I studies are under way. One set of data involving the race Tuxpeño (two years' data) is now being analyzed at North Carolina State College. Similar studies are under way or planted with varieties of the races Chalqueño, Cónico, and Nal-Tel, and with a varietal cross of Tuxpeño × Nal-Tel.

(7) Breeding methodology.

Mass selection studies are under way or planted with varieties of the races Tuxpeño, Chalqueño, Cónico, Nal-Tel, and Tuxpeño × Nal-Tel. Also, a recurrent selection program is being advanced in two populations, one a composite of varieties from the race Cónico. The other is of the same composite with germ plasm added from the races Celaya, Tabloncillo, and Cónico Norteño; these exhibit a great deal of heterosis in crosses with the modified composite.

(8) Random lines.

In order to understand better the comparative genetic structure of a modern incipient race in comparison with a primitive one, the races Tuxpeño and Nal-Tel are being inbred under the same conditions in an attempt to propagate as many lines as possible from a given number of original selfs in each variety.

(9) Relationship among primitive races in Latin America.

Relationships among the primitive races of maize of Mexico, Central America, Colombia, Venezuela, Ecuador, Peru, Bolivia, and northwest Argentina are being compared on the basis of morphological, physiological, genetic, and cytogenetic characters. At this stage of the study, Nal-Tel, Chapalote, Pollo, and a primitive form from Venezuela, all appear to be quite similar and could have come from the same early domesticated variety.

Palomero Toluqueño in Mexico and the high altitude pop corns of Ecuador, Peru, Bolivia, and Argentina also are all very similar in their characteristics, but as a group quite different from the Nal-Tel complex.

(10) Chromosome knob morphology of the different races of maize.

Dr. A. E. Longley, in collaboration with Ing. Angel Kato Y., limited their studies on chromosome knob morphology last year mainly to the primitive races of Latin America included in project (9) above. Many interesting data have been accumulated which are now being summarized for publication.

The Nal-Tel type collections examined from Yucatán, Campeche, Oaxaca, and Guerrero in Mexico and from Guatemala, El Salvador, Nicaragua, and Venezuela, were all strikingly similar in their knob morphology. The Chapalote race of Sonora and Sinaloa has a chromosome knob pattern very like that of Nal-Tel. The Nal-Tel types on the average showed a high percentage of plants with B-type and abnormal ten chromosomes, 17% and 13% respectively. However, these are not nearly as high as those in the race Pollo from Colombia, 100% and 47%, respectively.

These results are in very striking contrast to the high altitude pop corns of Mexico, Peru, Bolivia, and Argentina, in which no abnormal ten chromosomes were found in a total of 85 plants examined, but the number of B-type chromosomes found in this group was about the same as that for Nal-Tel. No abnormal ten chromosomes were found among the 20 plants examined from the race Chapalote.

A study of the chromosome morphology of the various races in Central America is now being made as an aid in determining more precisely the relationships among them.

Central American Regional Program

Central America produced a bumper crop of maize in 1960. There was a surplus in most of the countries—more corn grown than needed for direct human consumption. Yet the efficiency of production per unit of area continues to be extremely low in most regions and much remains to be accomplished.

During the past year special efforts were again made to stimulate cooperative work leading to the greater improvement of varieties, to the determination of fertilizer requirements, and to the control of insect pests and plant diseases. Also, where indicated, special assistance was given in seed production of improved varieties and in the demonstration of the value of this seed in combination with commercial fertilizers in bringing about a more efficient production of maize per unit of area.

The results obtained for 1959 have now been published and a similar report summarizing activities and results for 1960 is being prepared. The annual meeting at which last year's results were discussed and plans made for 1961 was held February 20–23, 1961, in Tegucigalpa, Honduras. The delegates were especially grateful to the Government of Honduras, which payed local costs of the meeting, including room and board for most of the official group.

The Coordinator's office was moved from Mexico to Managua, Nicaragua, on July 1, 1961. This is a more central location and the Ministry of Agriculture is providing excellent facilities for the multiplication of basic seeds and for experimentation of value to the region as a whole.

COOPERATIVE VARIETY TRIALS

In the cooperative variety trials, emphasis was continued on the evaluation of basic breeding materials. Seed of some of the most promising materials has now been increased and sent to various local breeders.

Trials of intervarietal crosses have been especially fruitful in identifying outstanding germ plasm. Certain varieties of the Tuxpeño race of Mexico give exceptionally good yields in combination with certain varieties of the Salvadoreño race which prevails in the lowlands of Central America.

Furthermore, certain Tuxpeño varieties, in combination with the synthetic variety Eto of Colombia, which has a great deal of germ plasm from the Caribbean, have yielded as much as the Mexican hybrid H-503. In years with good rainfall distribution, H-503 has been the highest yielding variety in the area.

In another experiment, not yet completely analyzed, it is directly evident that Tuxpeño combines well with some of the dark yellow Cuban flints and West Indian dents of the Caribbean area.

Another very significant recent discovery is that certain varieties from the Caribbean give excellent yields in combination with the Salvadoreño race. A very productive early hybrid, now ready for multiplication and release in Nicaragua, has been developed from these two germ plasm complexes.

It now seems clearly established that Tuxpeño combines well with Salvadoreño and certain races from the Caribbean; also, the latter two combine well with each other. This work identifies three excellent types of germ plasm for the further improvement of maize in Central America. A combination of these three germ plasm complexes in varying proportions into synthetic varieties or hybrids should result in the development of some "super-varieties" well adapted to the soils and rainfall of this important corn-producing area.

Although the demand in Central America is largely for white corn, some attention has been given to the development of improved yellow varieties. These will be especially useful in Panama where, in contrast to the rest of the region, the demand is for yellow types. Results obtained in this phase of the work have also been very promising. The most consistently high-yielding variety cross in Central America, from Guatemala to Panama inclusive, during the last two years has been Cuba 40 × Hawaii 5, two yellow varieties. Yields of this varietal hybrid are equal to those of H-503 and it is about 5 days earlier in maturity. The crosses Cuba 40 × SLP-104 and Hawaii 5 × SLP-104 yielded almost as well. Here again is evidence that excellent progress might be made through the combination of three germ plasm complexes, namely, Cuban yellow flint represented by Cuba 40, Yellow Tuxpeño represented by SLP-104 from the lowlands of San Luis Potosí, Mexico, and a mixture of Caribbean and United States corn belt germ plasm represented by Hawaii 5.

Cuba 40 and Hawaii 5 are being multiplied in Panama this year, in anticipation of the commercial production and distribution of hybrid seed made by crossing these two varieties. SLP-106 is also being increased, in case it too may prove useful in combination with Cuba 40 or Hawaii 5 as a varietal hybrid. In addition, all three varieties are being combined into a synthetic to be mass selected for a number of generations and then evaluated as an improved open-pollinated variety. As a matter of fact, the intervarietal hybrid is only an intermediate step in the production of an improved open-pollinated variety, equally as good or better, since the production and distribution of hybrid seed in large volume presents certain problems which will take time to solve.

With the basic materials now well identified, special emphasis is being placed on the development of synthetic varieties. Several blends of Tuxpeño, Salvadoreño, and Caribbean germ plasms have been made up. These will be propagated for several generations through open-pollination before programs are begun of mass selection, recurrent selection, and chain crosses in the attempt to develop outstanding improved open-pollinated varieties for large-scale distribution to farmers. Such varieties should also serve as excellent material for further improvement through the hybrid method.

In the uniform yield test of late hybrids planted in 11 locations from Mexico to Panama, the new Mexican H-507 gave consistently high yields throughout the area, yielding well in 9 of 11 trials. The two places where it was not too well adapted were at higher altitudes in Costa Rica. Others that were not significantly different in yield and maturity from H-507 are Poey T63, Poey T23, Guaicapuro, D-61, and H-501.

The hybrids Guaicapuro and D-61 were developed in Venezuela from Tuxpeño germ plasm. All these are considered to be a little late in maturity for the average climatic conditions of the area. Hybrids equal to H-507 in yield but from 8 to 10 days earlier in maturity, are badly needed for average rainfall conditions. The new varieties in process of development from the Tuxpeño—Salvadoreño—Caribbean blends are exceedingly promising in this respect.

PREVALENCE OF THE VIRUS DISEASE "STUNT"

The virus disease commonly known as "stunt" caused considerable damage this year in the lowlands of Guatemala and El Salvador. Some fields of the hybrid H-503 were a complete loss. In fact, all varieties of the races Tuxpeño and Salvadoreño in the area were quite susceptible, whereas some of the Poey hybrids appeared to be more resistant. The disease caused a good deal of alarm and several pathologists in El Salvador, in collaboration with the geneticists, are dedicating almost full time to a project of evaluating a wide diversity of materials for resistance.

COOPERATIVE FERTILIZER TESTS

Cooperative fertilizer experiments were carried out in Guatemala, El Salvador, Nicaragua, Costa Rica, and Panama to study the response of corn to nitrogen, phosphorus, and potassium under different soil and climatic conditions. Although a total of 17 experiments was planted, only 11 were deemed worthy of harvest. These were distributed on three different soil types, as follows:

Zone A. (Six experiments) Light to medium-textured soils formed on volcanic ash at elevations less than 200 meters above sea level, varying in color excluding reddish tones.

Zone B. (Three experiments) Red soils.

Zone C. (Two experiments) Soils of any color except red, located at elevations greater than 500 meters above sea level.

The number of experiments in each zone was too small for precise recommendations. However, on the basis of the meager data, the following tentative recommendations for each zone can be made:

Zone A. 30-0-0 (kg./ha. of pure N, P_2O_5, and K, respectively).

Zone B. 60-60-0.

Zone C. 60-0-0.

These recommendations are quite conservative. In Zone A an average of only 11 kg. of grain was obtained per kg. of nitrogen applied. These results are similar to those reported for the lowland high-rainfall tropical areas of Mexico. The low efficiency in these areas is due, in part at least, to nitrogen losses by leaching and to the uptake of nitrogen by weeds during the first few weeks after planting. How best to apply nitrogen under high-rainfall tropical conditions will need to be studied more extensively.

The results in Zones B and C were much more encouraging and indicate that up to 20 kg. of corn might be expected from each kg. of nitrogen applied (in Zone B in combination with phosphorus). In the highlands of Guatemala, responses to nitrogen are very great, as in the highlands of Mexico, and good returns can be expected from applications of 100–120 kg. of N per hectare.

INTER-AMERICAN YIELD TESTS

The types of tests that have been so successful in Central America have been extended to South America and north to the United States. In order to obtain some information on the potential value of different germ plasm complexes in different areas of Latin America, ten outstanding dent varieties were each crossed with ten outstanding flint varieties, regardless of grain color. These varieties are listed on the opposite page, together with their classification and origin.

The 100 resulting crosses have been tested in Mexico, Brazil, Peru, and Colombia, and are presently planted in Central America and in Mexico at Cotaxtla. The only results available at the moment are those from the winter breeding nursery at Tepaltzingo, Mexico. Though not completely analyzed, the results were obtained in a fairly neutral environment

Variety	*Probable Race*	*Origin*
DENTS		
Azteca	Yellow Tuxpeño	Brazil
Mex. White Synthetic	Tuxpeño	Brazil
Paulista Dent	USA Southern Dent	Brazil
Capitein	Tuxpeño	Mexico
Mix. I	Tuxpeño	Guatemala
Diacol V-101 (Synthetic)	Tuxpeño—Común	Colombia
Carmen	Early Tuxpeño	Mexico
I-452	Salvadoreño	Costa Rica
Venezuela 3	*White*—W. Indian Dent—Flint	Venezuela
Cuba 28	West Indian Dent	Cuba
FLINTS		
Venezuela I	Caribbean Flint	Venezuela
Nariño 330###6	Caribbean Flint (?)	Colombia
Peru 330 × Nariño 330	Caribbean Flint (?)	Colombia
Cateto	Cateto	Brazil
Cristal Blanco	White Flint (?)	Brazil
Diacol V-351 (Synthetic)	(?)	Colombia
PD(MS)6	Caribbean Flint	Cuba
Florida Flint Synthetic	Caribbean Flint	Florida
Amarillo Salvadoreño	Caribbean Flint	El Salvador
Eto Synthetic	Caribbean Flint—Común USA Dent, etc.	Colombia

and are exceedingly interesting. Each of the dents listed below yielded well in combination with each of the flints. Yields ranged from about 15% to 30% more than the better of the two parents and in each case were approximately equal to or better than those of the Mexican hybrid H-502, which is well adapted to the area.

DENTS	FLINTS
Mex. White Synthetic	Diacol V-351
Mix. I	Eto
Capitein	PD(MS)6
Carmen	Peru 330 × Nariño 330
Cuba 28	
Venezuela 3	
Paulista Dent	

Florida Flint Synthetic, Amarillo Salvadoreño, Venezuela I, and Peru 330###6 were only slightly less spectacular in crosses with the white Tuxpeños above than the four flints listed. Since there were no sharp differences in combining ability between the different varieties of Tuxpeño in crosses with the different varieties of Caribbean flints in this experiment, it appears that the excellent combining ability exhibited is a racial trait and of a general nature. It will be interesting to see if this observation is borne out when all the available data are analyzed.

During 1959 and 1960 a series of varieties from the Caribbean and races from Mexico and Colombia were crossed to the two single crosses in the corn belt hybrid AES801 and a corn belt composite. These crosses were planted in Argentina in October, 1960, and in Mississippi, North Carolina, Nebraska, and Indiana in the United States. They were also planted in the winter breeding fields at Tepaltzingo in December, 1960. The tests here have just been harvested. They were planted in the Bajío of central Mexico in the spring of 1961. Although the results from the Tepaltzingo experiments are not completely analyzed, certain observations have been made:

(1) Of the 35 races crossed to the corn belt composite, the following appeared to be the most promising: Eto Blanco, Tuxpeño, Tepecintle, West Indian Dent, Tuson, Chandelle, and four varieties that might be classified as Caribbean Flint: PD(MS)6, Amarillo Salvadoreño, Florida Flint Synthetic, and Peru 330 × Nariño 330.

(2) Of the 37 varieties, mostly from the Caribbean, crossed to the male single cross of AES801, the following races or varieties showed the most promise: Florida Flint Synthetic, PD(MS)6, Peru 330 × Nariño 330, and Eto, Tuxpeño (both yellow and white), and the West Indian Dents.

(3) The races that were good in crosses with the male single cross of AES801 also tended to be the best with the female single cross of AES801.

AMERICAN TROPICAL GERM PLASM IN SOUTHERN EUROPE, INDIA, AND SOUTHEAST ASIA

Last year the director of the maize project spent four months studying the maize programs and native germ plasm complexes in Europe, India, and Southeast Asia. In northern Europe, the plant breeders have developed some very high-yielding early-maturing varieties adapted to the generally cool climate of this area. Yields of 100 bushels per acre have been obtained with these relatively short-stalked varieties by crowding a high population of plants into a unit area. Some of this germ plasm will most certainly be useful in moving corn further north and south in the Americas.

In southern Europe, a great deal of improvement has been obtained through the introduction of inbred lines and hybrids from the United States. In some areas hybrids introduced from the United States are being used directly with much success, but usually it has been found that higher yields can be obtained through combinations of United States inbred lines with inbred lines developed from local varieties evolved from ancient introductions.

From a brief study of the native varieties, principally in Italy, Austria, and Yugoslavia, it appears that most of the older varieties here have developed directly from the interhybridization of ancient introductions from the Caribbean and Andean regions. This is the only place in the world where these two germ plasm complexes have intermixed on a large scale and the result is some outstanding open-pollinated varieties. This native germ plasm is only in the early stages of exploitation. It certainly warrants much greater study which could be of real value in the further improvement of maize, not only in southern Europe, but also in the corn belt of the United States and in southern South America.

In India, most of the old early-maturing varieties appear to have evolved directly from ancient introductions from the Caribbean area. In themselves they are not very productive, but in combination with some of the modern incipient varieties now prevalent in Mexico, Central America, Colombia, the Caribbean, and the United States, their yields can be very greatly improved. As a matter of fact, India has a tremendous range of germ plasm from which to draw. Strangely enough, most of the lowland varieties from the American tropics and northern temperate zone show quite good adaptation there. Because of the extreme variation of available germ plasm, the possibilities for varietal improvement are extraordinarily great in India. The blends resulting from work in India could establish the basic materials for rapid improvement of maize in other areas of Asia.

A brief visit to Nepal revealed that most of the native varieties in the mountains there have also developed from the interhybridization of the same materials as in southern Europe. Apparently the Andean-Caribbean germ plasm complex prevails from Europe all the way across to Asia in mountainous areas. At Katmandu, Amarillo de Cuba, a Cuban blend sent from Mexico, was yielding very well, although generally too late in maturity for the cropping systems. Its influence on the native types through interhybridization was, however, quite conspicuous.

In Thailand, the main commercial variety was found to be Tiquisate Golden Yellow, a variety developed in Guatemala by blending certain introductions from the Caribbean. It is highly probable that other introductions of Caribbean varieties would be of real benefit to this country.

In the Philippines, as in India, big increases in yield can clearly be obtained by combining the native germ plasm of ancient Caribbean origin with some of the lines and varieties from Mexico, Central America, and Colombia.

Throughout the trip it was apparent that the outstanding materials developed or identified in the breeding programs of Mexico, Colombia, and Central America are a veritable gold mine for the improvement of maize in India and Southeast Asia. With these materials, a tremendous impact can be made on the improvement of maize in Asia, with a relatively small amount of effort.

TEMPORARY RESEARCH AND TEACHING AIDES

The research and teaching program in the new Graduate School at Chapingo again benefited greatly from the aid of certain scientists during the past year:

(1) H. L. Everett, Ph.D., Professor of Genetics, Cornell University; Special Teaching and Research Aide in genetics; January 1—December 31, 1961.

(2) A. E. Longley, Ph.D., Cytogeneticist, Agricultural Research Service, U.S.D.A., retired; Special Temporary Research Aide in the cytogenetics of maize, Graduate School, Chapingo; April 1—September 30, 1961.

(3) O. E. Nelson, Ph.D., Professor of Genetics, Purdue University; Special Research Aide in studies on the distribution of the gametophyte factors Ga/ga in the Mexican races of maize; April 27—May 10, 1961.

(4) D. L. Thompson, Ph.D., Agricultural Research Service, U.S.D.A., and North Carolina State College; in charge of Corn Breeding Program in North Carolina; Special Research Aide in determining stalk strength of the many different varieties of maize in Mexico; June 6—24, 1961.

LATIN AMERICAN SCHOLARS

(1) Luiz Torres de Miranda, Ingeniero Agrónomo; Campinas, Brazil. Terminated his studies in October, 1960.

(2) Osvaldo Trivelli, Assistant to the Director of Agricultural Research, Catholic University Experiment Station, Pirique, Santiago, Chile. March 3, 1961—March 2, 1962.

VISITORS

(1) M. N. Harrison, Plant Breeder, Kitale, Kenya, Africa. Spent about three weeks with the project, studying the variation of maize in Mexico.

(2) P. M. Chinwuba, M.S., Corn Breeder, Federal Experiment Station, Ibadan, Nigeria. Spent three months in Mexico studying maize types and breeding methods.

The wheat project is providing advanced training for scientists from the Middle East, Africa, and South America.

Wheat

During the latter part of 1960 the director visited a number of wheat-producing countries in Central and South America, completing reconnaissance begun in the fall of 1959. In the former year the visits included Mexico, Colombia, Ecuador, Peru, Chile, and Argentina. In 1960, Brazil, Uruguay, Paraguay, Bolivia, and Guatemala were visited. Some general conclusions based on these observations are given below.

During the year 1960–1961 results from the first uniform yield nursery began to be received, and an improved nursery for planting in 1961 was assembled and shipped. One of the interesting results of the first nursery, as revealed by preliminary analysis, is the wide range of adaptation of certain high-yielding varieties in contrast to others whose high yield seems specific to certain climatic and related conditions. A new uniform nursery was designed specifically for the wheat-growing countries of the Near East, and the materials increased and shipped in 1961.

A number of research projects were continued or initiated during the year in collaboration with the National Institute of Agricultural Research of the Mexican Ministry of Agriculture, and with the Graduate School of the National School of Agriculture, Chapingo, Mexico. Several of these concerned the multilineal varieties developed by the National Institute.

Training of wheat specialists continued a central preoccupation of the project. Since the beginning of the project in early 1960, some 12 scientists from 10 different countries have spent 6 months or longer gaining advanced experience in wheat improvement methods.

Wheat Improvement in Latin America

The purpose of the reconnaissance trips in 1959 and 1960 was to obtain first-hand knowledge of wheat production problems, and of research programs, personnel, and facilities in the several countries.

One clear impression based on the two trips is the great shortage of scientific personnel in all the wheat-producing countries in Latin America. This shortage extends across all the scientific disciplines on which wheat production is based, but is more critical in certain ones than in others. Very few of these countries have teams of trained scientists, from the disciplines of plant breeding, soil science, plant pathology, entomology, and cereal technology, who can work together in attacking the problems which are important in wheat production and utilization.

WHEAT BREEDING

Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, and Peru all have wheat-breeding programs geared to the needs of the individual country. Varietal testing in Bolivia, Guatemala, and Paraguay is adequate from the standpoint of varietal needs, in relation to the importance of this crop in each of these countries. Even in countries with adequate breeding programs, however, there is still an extreme shortage of trained personnel in plant breeding.

Some countries, such as Argentina, Chile, Colombia, Peru, and Ecuador, are attempting to remedy this shortage through aggressive training programs. The training is usually on two levels. The first is practical training on local wheat-improvement projects to give young scientists proficiency in the use of plant breeding techniques and in program orientation. In a second phase, as many of these young scientists as possible are sent for study at a graduate school, either within the country itself or in some foreign institution, to acquire the necessary theoretical background. Within a foreseeable future, the number of adequately trained wheat breeders in the aforementioned countries should thus increase enough to allow a more efficient job of varietal improvement.

The greatest single bottleneck to higher wheat production in all Latin America is inadequate knowledge of soil fertility factors. A great deal of circumstantial evidence indicates severe deficiencies in one or more essential plant nutritional elements, which greatly limit yields in virtually every country in Latin America where wheat is grown.

Very few trained soil scientists are to be found in these countries, and of these only a few—perhaps no more than three in all South America—are actively engaged in full-time soil fertility research related to wheat production. This is strikingly inadequate in proportion to the needs. The lack of soil scientists is even more serious when it is considered that most of the better plant breeders, concentrating on breeding for disease resistance and grain quality, pay little or no attention to correcting the limiting factor of soil fertility.

In the past their tendency has always been to breed wheat varieties adapted to the very inadequate soil fertility conditions that exist in large geographical areas. It would be much better, for ultimate production, to spend a proportionate sum of money on research to solve the basic soil fertility problem, and when this is done, to breed new varieties to fit the improved soil conditions.

SOIL SCIENCE

The paucity of knowledge on soil fertility is evidenced by the very small amount of chemical fertilizer currently used in wheat production in Latin America. Mexico and, to a lesser extent, Colombia, Ecuador, Guatemala, and Chile are the only countries where anything like sufficient amounts of chemical fertilizer are employed to increase wheat production. Mexico uses far more chemical fertilizer for wheat than does any other Latin American country.

It is especially curious that in Argentina even today no chemical fertilizer is used in wheat production. Moreover, in this country, where alfalfa grows extremely well and fits beautifully into the wheat and livestock production pattern, there has been no marked tendency to shorten and intensify the alfalfa and grass-wheat rotations to offset nitrogen depletion. Only within the past three years have modest steps been taken to initiate research on the soil fertility aspects of wheat and corn production in certain areas.

Soil fertility problems are serious and perhaps even more complex in vast areas in southern Brazil, parts of Uruguay, and in southern Chile. Until the deficiencies are corrected, yields of both forage and wheat will remain extremely low.

The shortage of soil scientists with an interest in soil fertility cannot be corrected rapidly, but it is urgent that every effort be made to stimulate as many young people as possible to devote their scientific careers to this special discipline. Unless this can be accomplished, increase in wheat production in South America will, for the most part, be very slow. The only exception will be where an individual breeder may have the unusual combination of interest, background, and training to permit him to make simultaneous advances in both varietal improvement and agronomic practices.

PLANT PATHOLOGY

The number of plant pathologists in Latin America specializing in wheat diseases is still very limited. The contributions which this small group has made to wheat improvement have been directed, almost without exception, toward the control of rust diseases. In almost all instances their work has been done in close cooperation with the plant breeders in their respective organizations and countries.

Other plant pathological problems, however, of great importance in wheat production, remain unsolved, having received little or no study. In Brazil and Argentina, growers periodically suffer heavy losses from scab (*Fusarium*) and from the *Septoria* diseases, both *S. nodorum* and *S. tritici*. Whether these diseases are more severe in these regions because of climatic conditions or because they are in some way associated with soil deficiency, is not clear at present.

A vast amount of basic research must be done before varieties resistant to these diseases can be developed. At present no one in Latin America is seeking to gain this background information. If it proves that the genus *Triticum* lacks resistance for control of these diseases, then research must be undertaken to find it in related genera, and to transfer it, when found, to *Triticum*. This is only one of the problems which indicates the need for more well-trained plant pathologists specializing on wheat.

ENTOMOLOGY

Entomological factors affecting wheat production in Latin America seem for the most part to be of less importance than those previously mentioned. There are, however, a number of virus diseases of small grains in South America, some of which are insect transmitted. More information is needed on these; not only are some of them important in local production, but they might also be extremely dangerous if introduced into other wheat-producing areas of the world.

QUALITY CONTROL

The question of wheat quality is of primary importance to exporting countries and to those which are self-sufficient in the production of this cereal. In most countries where the amount of money available for research on wheat is limited, first priority must be given to the solution of problems immediately connected with production. This generalization is especially applicable to importing nations, and it is true in virtually all Latin American countries at the present time. Argentina and Mexico are the only ones which are self-sufficient or exporters. Argentina, the only wheat-exporting nation in Latin America, has done much research on wheat quality over the past 25 years.

In 1935, Argentina began a program to improve wheat quality and to control and standardize it in foreign exports. Since then a considerable number of capable cereal technologists have been developed. Some of these are members of private seed companies actively engaged in varietal improvement; some are employees of the domestic milling industries; and a large number are with the Federal Grain Board. In Argentina at the present time, varietal quality is a primary consideration in all breeding programs, whether conducted by private seed companies or by official agencies.

The Wheat Quality Laboratory in Mexico was not established until 1957. Prior to that time all research funds allocated to wheat had been used in projects related to production. When Mexico achieved self-sufficiency in wheat production in 1956, it became necessary to solve the quality problems locally rather than to rely on blending with imported wheats of superior gluten quality. During the past two years a great deal of emphasis has been put on developing and comparing micromethods for gluten quality determinations in early generations.

In addition to Argentina and Mexico, where considerable emphasis is now given to wheat quality in breeding programs, good cereal chemistry laboratories are available, or are being installed, in Colombia, Chile, and Peru.

RESEARCH FACILITIES

At present, a number of countries have or soon will have excellent facilities for conducting research on all phases of wheat improvement. The list includes Argentina, Chile, Colombia, and Mexico. In Argentina the recently created federal research agency, the National Institute of Plant and Animal Technology (Instituto Nacional de Tecnología Agropecuaria, "INTA"), has begun to construct nine regional centers, several of them in the wheat-producing areas, which will have very good facilities of land, laboratories, and equipment for all the different types of investigations needed for wheat improvement. In addition, the main center of the Institute, at Castelar, is beautifully equipped for the basic studies needed to support the applied work at the regional centers. The development of this network of research centers calls additional attention to the urgent need for more trained personnel.

In Chile, at "La Platina," the central agricultural research center near Santiago, good greenhouses, laboratories, and plots are or will soon be ready for work on spring wheats. A similar center is being constructed at Temuco in the winter wheat belt, where work on winter wheats and soil fertility will be concentrated. Temuco is in an area with one of the most serious soil fertility problems in southern South America.

Facilities for wheat research in Colombia are excellent, most of the work being concentrated at Tibaitatá, near Bogotá. At this center good greenhouses, laboratories, and plots are available.

The research work in Mexico is more decentralized than in most of the other countries. During the winter—the irrigated commercial crop season—the main breeding work is concentrated at the Northwest Agricultural Research Center (CIANO) in Ciudad Obregón, Sonora, and in the regional center in the Bajío, previously located at La Piedad, Michoacán, and now moved to El Roque, Guanajuato.

In the summer, work is largely confined to the El Horno research center, Chapingo, and to the Santa Elena experiment station in the Valley of Toluca. All greenhouse procedures on plant resistance are conducted at Chapingo, as are those on wheat quality. Both the resistance and the quality projects are limited by inadequacies in physical installations and equipment.

In most of the other countries the basic installations for plot work are available, in a few cases supplemented by very small greenhouse facilities for disease-resistance studies, but special equipment and personnel for carrying on other types of investigations are not yet a reality. In many of these countries it would be unwise to attempt to develop complete installations for work on all phases of wheat improvement. Much of the information obtained in centers in neighboring countries where wheat production is of primary importance can be applied locally.

INTERNATIONAL COOPERATIVE RESEARCH PROJECTS

INTER-AMERICAN WHEAT YIELD NURSERY

The first Inter-American Wheat Yield Nursery was sent to collaborators during May of 1960. The purpose of the yield test is to obtain basic information on the relative adaptability of a uniform set of commercial varieties and experimental lines to different climatic, soil, and biological conditions. It is generally recognized that wheat is a crop with great flexibility of adaptation. It is grown from the equator to latitudes of more than 60°, and from near sea level to more than 13,000 feet in some tropical countries where elevation compensates for latitude. It has also been learned through observation that certain varieties, such as Mentana, have a much wider range of adaptation than others such as Thatcher. However, no comparative data collected under controlled conditions have been obtained to support such observations or to elucidate the underlying factors which determine adaptation.

The first inter-American nursery consisted of 25 varieties planned to represent the principal spring wheat types grown in the Americas. In several cases, however, varieties chosen for the test had to be omitted because the seed from the collaborating countries did not arrive in time to be multiplied. As a result, the 1960 test was less representative than the one for 1961, which was sent out in the spring.

The 1960 test was sent to 14 collaborators in 9 countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, and Peru. A list of these principal collaborators and their locations appears on pages 260-261.

In addition, several units of the test were sent to collaborators outside Latin America who had requested an opportunity to participate. These included workers in Australia, India, Kenya, Pakistan, and the United Arab Republic; they are listed on pages 261-262.

The data from the 1960 test were being compiled at the end of the period covered by this report. In the future, it will be necessary to prepare these data in two sections to present the results more promptly, since the experiments are planted in two hemispheres.

In general the first year's test produced some interesting results. It became clear that certain varieties were high-yielding under a wide range of conditions, from high latitudes to equatorial zones, whereas others were very specific in their adaptability as measured by yield performance. Some varieties were also very sensitive to latitude changes with respect to maturity, whereas others were relatively insensitive.

This first year's results will serve as a guide for future improvement of this nursery. Current plans call for dividing the varieties into two separate units. One will be a permanent set used each year to serve as a reference point for year-to-year comparisons. The second will include newer materials developed by cooperating countries, and will be changed from time to time as the situation warrants.

NEAR EAST-AMERICAN WHEAT YIELD NURSERY

It became clear during the course of the trip that the director made to the Near East in 1960 that many of the lines and varieties of wheats from the low latitude zones of the Americas, especially from Colombia and Mexico, were well adapted to a number of Near East countries. Through the joint efforts of the Food and Agriculture Organization of the United Nations, the National Institute of Agricultural Research of Mexico, and The Rockefeller Foundation, a second uniform nursery will be grown. The 25 varieties in this test are of spring habit and are largely from the Near East, Mexico, Colombia, and Australia. They are varieties which for the most part are insensitive to length of day. The seed of the chosen entries was grown under uniform conditions at CIANO during the winter of 1960–1961 and the packets, prepared by FAO scholars in Mexico, will be sent out during July, 1961. Dr. Jose Vallega and Dr. James E. Harrington will handle the distribution of this nursery from Rome. They will also be responsible for the gathering and compilation of data and publication of results.

Cooperative Research in Mexico

Through the cooperation of the National Institute of Agricultural Research of the Ministry of Agriculture and the Graduate School of the National School of Agriculture, a number of cooperative research projects were carried on during the year in Mexico.

MULTILINEAL VARIETIES

For over three years, studies have been continued on several of the principles underlying the development and use of multilineal or composite wheat varieties. These varieties are made up of lines which are phenotypically similar but genotypically different as regards resistance to stem rust. It is therefore necessary to follow the shift in these populations over a number of years to determine the feasibility of using them for seed production.

Populations of the multilineal variety Yaqui have been studied from the standpoint of yield, agronomic uniformity, and rust spread for the past three years. The first, second, and third generations after the original mixture have been compared with each other, with the recurrent parent, and with the individual lines used in the mixture. It is now apparent that the yield of the third generation is not significantly different from that of the first generation following mixture. Neither are there discernible shifts in the general agronomic characteristics of the variety. It is becoming increasingly apparent that these mixed populations, in the absence of severe epidemics of rust caused by one or more races, are not as sensitive to population shifts as had been predicted by some scientists. There does not seem to be any evidence to indicate any serious problem in the use of composite varieties, from the standpoint of seed production. These studies have been conducted in collaboration with Dr. Ignacio Narvaez, Ing. Gregorio Vásquez, Ing. Alfredo García, and Ing. Silvestre Espino of the National Institute.

During the past two years, a basic study has been made on the rates of spread in mixed populations (i.e., multilineal varieties) involving backcrosses resistant and susceptible to a given race of stem rust under field conditions. Two pure backcrossed lines, one susceptible and one resistant to the tester race, were grown independently and mixed in different proportions. Individual susceptible plants in the center of each plot were then inoculated with the tester race of stem rust, and the rate and intensity of spread of the infection followed through two or three subsequent generations of the pathogen, or until such time as the inblown inoculum from outside areas masked or confused the infection derived from the original center of inoculation. It is now evident, as was previously theorized, that in mixed populations in which 80% of the plants are resistant, the rate of spread from the primary infection is much slower than in a homogeneous population. In mixed populations there is a heavy mortality in inoculum from the primary infection, especially during the first two generations. This is reflected in both a reduced rate of spread and a reduction in intensity of infection in the mixed population over that of the "pure line" population.

The reduction in the rate of spread from the primary infection in the early generations delays the build-up of an epidemic and permits the mixed population, including the susceptible plants, to produce a satisfactory crop of grain.

DWARF MULTILINEAL VARIETIES

Following the release of the first dwarf varieties, which were received with great enthusiasm, it has become necessary to convert as rapidly as possible the Multilineal Yaqui and Lerma varieties to the corresponding dwarf forms. This need had been anticipated and the steps necessary to attain the objective are well advanced.

The research work on the basic principles underlying a better understanding and use of multilineal varieties has been done in collaboration with Dr. Alfredo Campos T., of the Graduate School, Chapingo, and with Ing. Silvestre Espino, of the National Institute.

RESEARCH ON DWARF LINES

For the past seven years, a large amount of work has been done to develop high-yielding, disease-resistant dwarf bread wheat varieties. The genes for dwarfness were originally transferred from the Japanese variety Norin 10 by crosses with spring and winter wheats, made in Pullman, Washington. The extreme susceptibility of the dwarf lines originally received from Dr. Orville Vogel of the Washington State Agricultural Experiment Station and used as a parent in the first cross, made in Mexico, made necessary the crossing and recrossing of a large number of combinations in order to obtain lines and varieties with the desired agronomic and disease-resistance characteristics. Several of these varieties have been released in the past year by the National Institute for commercial production in the West Coast and the Bajío regions of Mexico. They have been highly successful because of their resistance to lodging, excellent yielding ability, and resistance to stem rust. These first varieties do not, however, possess the gluten characteristics that are most desirable for Mexican wheat production. Through early generation quality testing, several thousand individual plants have been evaluated during the past year, in an attempt to isolate parental lines possessing outstanding gluten quality in both the hard and soft wheats. The best of these lines will be used to recross with the commercial dwarf varieties, Pitic 62 and Penjamo 62.

DEVELOPMENT OF DWARF DURUM VARIETIES

One of the principal limitations governing the cultivation of durum wheat varieties under irrigation has been their extreme straw length. As a result, the durum varieties when grown under irrigation are, without exception, extremely susceptible to lodging. Moreover, the durum wheat varieties (*T. durum*), as well as those of *T. turgidum*, are further restricted in the areas where they can be successfully cultivated by their extreme susceptibility to *Puccinia glumarum*.

Although durum wheats of winter habit have been reported by Vavilov, there do not seem to be any with clear-cut winter habit available for commercial production. Some of the Iranian and Turkish durums are of intermediate habit, but none seems to have any strong degree of frost resistance. If these three aforementioned defects could be overcome by the formation of a new variety or group of varieties combining the necessary characteristics, durum and turgidum wheats could be given a more flexible pattern of adaptation.

Three years ago, the Japanese dwarf genes were transferred from some of the most promising Mexican dwarf bread wheat lines (*T. vulgaris*) to *T. durum* and *T. turgidum*. This was the first time that this transfer had been made. Since then, four additional backcrosses to durum or to turgidum wheats have been made, and during the past season lines from these backcrosses were isolated which combined dwarfness, complete fertility, excellent agronomic characteristics, and good stem-rust resistance. Many of these lines also possess excellent grain characteristics. It appears highly probable that within the next two years outstanding commercial varieties of both durum and turgidum types of spaghetti and cracker production, respectively, will be obtained from this material.

It is not yet clear whether lines will also be recovered which will combine an adequate degree of resistance to stripe rust. If these are not found, the best durum and turgidum dwarf lines will be recrossed to Ethiopian durums, the only source of high rust resistance available in durums, and to certain bread wheat varieties that possess a high degree of resistance to *Puccinia glumarum*. Following the making of such crosses, if they are necessary, backcrosses will be made to the improved durum lines in order to select a desirable type combining the characteristics incorporated in the recurrent parent with the additional resistance to stripe rust from the donor parent.

The aforementioned steps are being conducted in Mexico in collaboration with Dr. Ignacio Narvaez, Ing. Alfredo García, Ing. Gregorio Vásquez, and coworkers.

A third step in the conversion of the best Mexican dwarf durums to winter habit will be made in collaboration with Dr. Robert Romig of the Chilean Agricultural Program. The best Mexican dwarf lines will be crossed to French winter-habit bread wheats, and subsequently recrossed to Mexican dwarf durum lines. It should be possible to recover winter habit from the French varieties, and perhaps also resistance to stripe rust, since such French varieties as Cappelle Desprez possess both of these outstanding characteristics. If these characteristics can all be combined into a good durum wheat variety, it will mark a significant step in wheat improvement, not only for parts of Latin America but also for the Near and Middle East.

BROWN NECROSIS

For the past 30 years, there has been a great deal of confusion over the cause of a disease, or group of diseases, of wheat ordinarily called brown necrosis or black chaff.

Under these terms have been included the bacterial black chaff reported by Bamberg, and the melanosis or genetic black chaff, associated with Hope and H-44 type of stem-rust resistance, reported by McFadden, Waldron, Hart, and Allison.

This disease under certain climatic conditions may result in serious losses both in grain yield and in reduced grain test weight, as was the case when the variety Conley was released in the United States some eight years ago. Normally, however, the extremely susceptible lines are eliminated in breeding programs, whenever environmental conditions are favorable to an expression of this disease, and most new commercial varieties are resistant or moderately resistant. Nevertheless, under certain climatic conditions varieties which are moderately resistant can be badly damaged.

Plants affected by this disease exhibit brown to black discolored areas on any one of several parts of the stem. The areas most commonly affected are the glumes, rachis, upper culm, and the portion of the lower internodes unprotected by the leaf sheaths. In extremely susceptible varieties the chlorophyll system of the leaves is also affected, turning yellow in color.

The unfortunate experience with the variety Conley in the United States led to initiation of investigations by Dr. Glenn Smith and coworkers at North Dakota to determine the cause of this disease. His recently reported, but still unpublished, data indicated that Conley carries a gene which at certain critically high temperatures produces this brown necrosis or black chaff condition.

For more than ten years, various of the scientists working on wheat investigations in Mexico have noticed the increased intensity of this disease when varieties that are moderately resistant to moderately susceptible under winter irrigated conditions, are grown during the summer rainy season in high valleys. This greater susceptibility appeared in some way to be related to differences in light intensity and perhaps to light quality, and to differences in humidity.

Two years ago, studies were initiated in the Mexican Wheat Improvement Program to determine the causes of brown necrosis under local conditions.

Two different types of investigations were undertaken. Genetic studies in which crosses were made between susceptible and resistant varieties, carried out by Ing. Mario Vela and Dr. Ignacio Narvaez, indicated that several genes are involved in the brown necrosis or black chaff disease.

These workers have also found evidence to indicate that there are different genes which influence the development of this condition on different parts of the plant. The susceptibility to brown necrosis is dominant in F_1.

During the past summer, in the Valley of Toluca, experiments were initiated to attempt to determine whether light intensity and light quality were important in the development of brown necrosis.

Susceptible and resistant varieties of wheat were space-planted and several culms of individual plants were enclosed in cylinders formed with various plastic and cellophane films. The remaining culms of each plant were left exposed to normal atmospheric conditions. A total of 19 different films with different light transmission characteristics was included in this study.

Of the materials tested, three films, namely red, green, and blue cellophane, gave clear-cut preliminary evidence of protecting the plants against brown necrosis. All of these films had very low transmission in the ultra-violet range (from 2,600 to 3,600 Ångstrom units). This preliminary experiment indicates that part of the spectrum in the ultra-violet range contributes to the development of brown necrosis in varieties that carry genetic factors for susceptibility to this condition.

These preliminary results are being reexamined during the summer of 1961. In the current test, attempts are also being made to determine at what stage susceptible plants must be shielded from the ultra-violet rays in order to prevent the appearance of brown necrosis.

If the second year's results confirm those of the first year, additional studies will be made to try to determine what chemical changes actually are catalyzed by the ultra-violet bands of light.

These studies have been carried out in collaboration with Dr. Alfredo Campos T. and Ing. Silvestre Espino.

WHEAT QUALITY

In the past, most of the world's wheat improvement programs have been handicapped by the lack of appropriate tests for evaluating milling and baking quality in early generations. Most standard tests require grain samples of such size that it is impossible to begin quality tests before the fifth or sixth generation.

During the past year, the Wheat Quality Laboratory at Chapingo has been attempting to develop general background information that will result in the selection of the best types of tests for the evaluation of gluten quality of individual plants in the F_2 and F_3 generations, as well as others for use with slightly larger grain samples from the F_4 and F_5 generations. These efforts have up to now been primarily concerned with gluten quality, and in early generations no consideration has been given to milling quality.

Currently the laboratory is finishing the evaluation of gluten quality of all of the wheat varieties (more than 300 lines and varieties) included in the 1959 International Spring Wheat Rust Nursery. All the grain samples used in these tests were grown under identical conditions in Sonora in the winter of 1959 and 1960 and have been, or are now being, evaluated for gluten quality by five different methods, including the standard baking test. These data will soon be summarized and will serve as a valuable guide in determining what tests are best for use with early segregating plant populations in breeding programs. Since the Mexican breeding program is interested in the development of both high-quality hard and soft wheats, and since the production of these two types is not geographically separated, as is true in the United States, this program offers a universal challenge in devising testing methods that will serve as an accurate guide in selecting promising plants and lines in the early generation in each of these types of grain.

These investigations on quality testing methods adaptable to early generations in breeding programs are being conducted with the cooperation of the following representatives of the National Institute: Dr. Ignacio Narvaez M., Ing. Federico Castilla Chacón, Srita. Evangelina Villegas, and Ing. Arnoldo Amaya C.

TRAINING OF SCIENTIFIC PERSONNEL

The greatest single obstacle to wheat improvement in many countries of the world, as previously indicated, is the shortage of well-trained scientists in the various disciplines affecting wheat production.

During the 17 years of its existence, the Mexican Wheat Improvement Program of the Office of Special Studies (now consolidated in the new National Institute of Agricultural Research) not only functioned as a research program that contributed to the solution of many problems affecting wheat production, but, perhaps even more significantly, served as an organization that provided training and research experience for a large number of Mexican scientists. Most of the current staff of the wheat section of the National Institute received training in this program.

During the 17-year period, 16 young scientists from Latin America, most of them supported by Rockefeller Foundation scholarships, received training of from six months to one year each in various aspects of wheat improvement in the Mexican Agricultural Program. Of these 16, all but 2 continue to work in some aspect of wheat improvement in their respective countries. Included among the trainees are scientists from Guatemala, Colombia, Ecuador, Peru, Bolivia, Paraguay, Chile, and Brazil.

Many other scientists, not only from Latin America but from many other countries of the world, have spent shorter periods of time with the Mexican program. These scientists have been sponsored and supported by many different agencies.

Since the transfer of responsibility for Mexican wheat improvement to Dr. Ignacio Narvaez M. of the National Institute, more time is available for the director of the Inter-American Wheat Improvement Project to devote to training aspects, in collaboration with the National Institute. During this period, 12 scientists from 10 different countries have spent 6 months or longer in the training program. Included in this group are seven young scientists, from as many different Near East countries, who are sponsored by the FAO.

During the past year the following foreign scientists spent various periods of time with the Mexican Wheat Improvement Program:

FAO Scholars

The following scientists from countries in the Near East visited the Mexican Wheat Improvement Program on scholarships awarded and administered by the Food and Agriculture Organization of the United Nations. The scholarships began February 14, 1961, and are to extend to October 30, 1961. This FAO scholarship program is financed in part by a grant from The Rockefeller Foundation.

(1) Manzur Ahmad Bajwa, Assistant Botanist, Milleter, Cereal Section, Agricultural College, Lyallpur, Pakistan.

(2) Mansur Baraighith, Assistant Agronomist and Manager, Seed Multiplication and Distribution, Barce-Cyrenaica, Libya.

(3) Hosseim Kaveh, Chief of Wheat Breeding, Plant Breeding Center, Varamin, Iran.

(4) Huseyin Kutluk, Plant Breeder (Wheat), Seed Improvement and Experiment Station, Eskisehir, Turkey.

(5) Nafeh Orabi, Chief of the Agricultural Office, Latakia, Syria, United Arab Republic.

(6) Ghulam Sakhi, Ministry of Agriculture, Plant Protection Laboratory, Kabul, Afghanistan.

(7) Elham Talaat, Wheat and Barley Breeder, Sakka Agricultural Experiment Station, Cairo, Egypt, United Arab Republic.

Rockefeller Foundation Scholarship and Training Awards

The following scientists were with the Mexican Wheat Improvement Program on Rockefeller Foundation scholarship and training awards during the year:

(1) Alberto Luis Chabrillon, Ing. Agr., National Institute of Agricultural Technology, Experiment Station "Tezanos Pinto," Paraná, Entre Ríos, Argentina. March 1–August 30, 1961.

(2) Enrique René Ernié, Ing. Agr., Wheat Specialist, Experiment Station "Marcos Juárez," Córdova, Argentina. Beginning March 3, 1961.

(3) Pablo Larrea, National Wheat Commission, Quito, Ecuador. August 24, 1959–October 21, 1960.

(4) Marino Romero Loli, Ing. Agr., Cooperative Program for Plant and Animal Research, Huancayo, Peru. July 27, 1960–June 17, 1961.

Visitors

(1) Giles E. Dixon, Ph.D., Wheat Breeder, Wheat Breeding Program, Njoro, Kenya, Africa. Rockefeller Foundation Travel Grant, September 21–October 4, 1960.

(2) Astolfo Fumagalli, Ing. Agr., Wheat Technician, National Plant and Animal Institute "La Aurora," Guatemala. April 10–30, 1961.

(3) Ernesto F. Godoy, Ing. Agr., National Institute of Plant and Animal Technology, Pergamino Experiment Station, Buenos Aires, Argentina. Rockefeller Foundation Travel Grant, February 15–October 15, 1961.

(4) John Guthrie, Ph.D., Plant Pathologist, Plant Breeding Station, Njoro, Kenya, Africa. Rockefeller Foundation Travel Grant, April 8–26, 1961.

(5) A. Kritzinger, Ph.D., South African Embassy, Pretoria, South Africa. February 18–21, 1961.

(6) Albert T. Pugsley, Ph.D., Wheat Scientist, Agricultural Research Institute, Wagga, New South Wales, Australia. Rockefeller Foundation Travel Grant, February 3–27, 1961.

(7) Glenn Smith, Ph.D., Dean, Graduate School, University of North Dakota, Fargo. On invitation from the Crop Quality Council, Minneapolis, Minnesota; April 5–May 5, 1961.

Weighing a potato crop in Mexico.

Potatoes

The establishment of the Inter-American Potato Improvement Project represents a new addition to the Rockefeller Foundation program designed to accelerate the improvement of basic food crops in the Western Hemisphere. The successful initiation of international cooperative projects in maize and wheat improvement have demonstrated the value of this pioneering research approach.

Long before the new project was formally organized, however, international collaboration in potato research in Latin America was taking form through excellent but uncoordinated contacts between individual programs. In 1952, during the second Latin American Congress of Plant Scientists at Campinas, Brazil, steps were taken to establish this collaboration on a more efficient basis. Two projects were proposed to initiate this international activity: first, the establishment of a germ plasm collection, including both wild and cultivated forms; and second, coordination of research effort on the late-blight disease and its pathogen, *Phytophthora infestans*. These recommendations were formalized in a resolution adopted at the congress.

With Mexico as a coordinating center, the program began as a loosely organized exchange of materials and information. Collection of wild and cultivated species was increased in Peru, Colombia, and Mexico. A series of 10 Mexican selections resistant to late blight was distributed to 17 Latin American countries for testing under local exposures to this pathogen. Subsequently this material was sent for field trials and breeding purposes to 42 countries in all parts of the world.

During this time certain phases of the potato research program in Mexico and Colombia were assuming an international flavor. Mexican blight-resistant varieties were being sent to scientists in such places as Kenya, Ireland, and Japan. Results of research in Colombia were being extended to Ecuador and Venezuela. In Mexico, a world center for late-blight research was developing, with exchanges of material and cooperative testing being established with potato breeders not only in Latin America, but also in Scotland, the Netherlands, Germany, Canada, and the United States.

In 1960, the project director was granted a six months' leave for study with Dr. Wilhelm Rudorf at the Max Planck Institute in Cologne, Germany. During this time he also had an opportunity to visit several of the outstanding potato research centers in Europe, where many basic research projects were observed. This first-hand review of potato investigations revealed that there were still important problems that had not been touched and, perhaps more important, that some problems could best be solved by research in Latin America.

In January, 1961, Dr. Javier Cervantes R. and Ing. Santiago Delgado S. of the new National Institute of Agricultural Research assumed the leadership of the potato research program in Mexico. This significant development marked the attainment of one of the basic goals set by the Mexican Agricultural Program, namely, the training of young Mexican scientists to assume agricultural research leadership in their country.

At the same time, this transfer of national research responsibilities has allowed Rockefeller Foundation personnel to explore the opportunities for increasing the effectiveness of international collaboration in potato research in Latin America. In February and March, 1961, the director made a trip to Peru, Ecuador, Colombia, and Venezuela, to investigate the possibilities for developing closer contact and exchange between potato research programs, for helping them to be more efficient, and for initiating new research on basic potato problems of both local and international importance.

The potato is a native of Latin America. Four centuries ago it was taken from there to Europe, and subsequently became one of the basic food crops of the world, particularly in the temperate zones. In the course of spreading to the far corners of the earth, potato culture has been followed by many of the problems that complicated its existence in its native Latin American haunts. Research has often been able to solve many of these problems at the local or even national level. Some have remained essentially unsolved. One of the most interesting and attractive recent developments in potato research is the trend to return to the Latin American home of the potato, and to study how this plant developed and survived through many centuries of selection. This selection was both a natural one, in which there was survival of those best fit to resist natural enemies, and an artificial one, in which man chose to preserve those types that most adequately met his needs.

This research shift to Latin America has led to several important breakthroughs in potato research. Resistance to the virus diseases that plague potato growers everywhere has been found in a number of Central and South American wild species of *Solanum*, and a few of these are now being utilized in potato improvement programs. Attempts to increase the starch content of the tuber gave little promise of success until investigators turned to the study of the variation in this characteristic in certain wild potato species. Perhaps the most spectacular Latin American contribution has been in the development of potato varieties with a broader and more stable resistance to late blight, long the scourge of potato growers and today one of the world's most important plant disease problems. These developments, substantial though they may be in terms of research accomplishment, are only examples of the potential benefits to be derived from potato research.

Not only is Latin America the logical place to make an internationally important contribution through the study of the germ plasm of native potato species. It is in Latin America that these basic studies are so urgently needed, in those regions where the potato is so important and where the pressure for increased food production is so desperate. Strangely enough, potato yields in Latin America are among the lowest in the world, and it is significant that research and its applications can make the greatest impact here. The new Inter-American Potato Improvement Project is in a strategic position to develop and coordinate this research. This is the challenge.

International Rice Research Institute

Personnel

INTERNATIONAL RICE RESEARCH INSTITUTE

Robert F. Chandler, Jr., PH.D., Director, The Rockefeller Foundation
Sterling Wortman, PH.D., Assistant Director, The Rockefeller Foundation
Robert Letort, Treasurer, The Rockefeller Foundation
Loyd Johnson, M.S., Agricultural Engineer, The Rockefeller Foundation
Jose D. Drilon, Jr., B.A., Executive Officer
Federico Ramos, M.S., Assistant Field Superintendent

mitory, administration, and laboratory buildings under construction.
e roofed structures are temporary buildings used by the contractors.)

Director's Report

Rice, one of the principal food crops of mankind, is not a new subject for consideration by The Rockefeller Foundation. As early as 1953, when its officers began making exploratory trips throughout the agricultural regions of free Asia, the Foundation's long-time interest in the basic food crops was extended to include this all-important grain. Interest deepened into concern as it became evident that although half the world population depends upon rice as its chief source of food, average yields of this vital crop are seriously inadequate in the primary consumption areas, particularly in tropical and subtropical Asia.

Thenceforth, a number of Foundation grants of varying sizes were made to agricultural research and educational institutions in the rice-growing countries, mainly to promote the training of rice scientists and to support important rice research projects.

In 1958 it was learned that the Ford Foundation, also, considered additional research on rice in Asia to be of primary importance and worthy of support by their organization. After several meetings between officers of the Ford and the Rockefeller Foundations, it was agreed that preliminary investigations be made as to the feasibility of establishing in the Philippines an international rice research institute under the joint support of the two foundations.

Several trips were made to the Philippines by officers of both foundations, and the reception by Philippine officials of the idea of such an institute was most favorable. The College of Agriculture of the University of the Philippines expressed a desire to have the institute located in Los Baños and offered land for the buildings and for a portion of the experimental fields. It was learned, also, that additional land for experimental purposes could be purchased to satisfy the full needs of the institute. The Secretary of Agriculture of the Government of the Philippines indicated his willingness to help in making arrangements for the legal establishment of the institute on a tax-exempt basis.

In June, 1959, the trustees of the Ford Foundation appropriated the sum of $250,000 for the purchase of land and to cover the early developmental costs of the International Rice Research Institute. At the same meeting the trustees indicated their willingness to study a request for funds to meet all capital costs of the project. Early in 1960, the Ford Foundation appropriated an additional $6,900,000, which made their total contribution $7,150,000.

The Rockefeller Foundation provided $185,000 for costs of operation and equipment in 1959-1960, and granted $229,000 to cover such costs in 1961. In addition, The Rockefeller Foundation agreed to consider requests for funds to operate the Institute in future years; to provide the services of certain of its own agricultural staff; and to appoint one of its officers as director of the Institute. In October, 1959, an agricultural officer of The Rockefeller Foundation began an assignment in the Philippines; in April, 1960, at the first meeting of the Institute's Board of Trustees, he was formally appointed its first director.

In 1960, the International Rice Research Institute was incorporated under Philippine law as an autonomous, nonprofit, non-stock, philanthropic organization, and The Congress of the Republic of the Philippines passed a law granting the Institute complete freedom from all duties and taxes and exempting its foreign staff members from the payment of Philippine income taxes.

The Institute has as its governing body a 10-member Board of Trustees, at present composed of the following persons from six different countries: Dr. J. George Harrar, President, The Rockefeller Foundation (Chairman); Prince M. C. Chakrabandhu, Director General, The Rice Department, Ministry of Agriculture, Thailand; Dr. K. R. Damle, Secretary, Ministry of Food and Agriculture, Government of India; Hon. Cesar M. Fortich, Secretary, Department of Agriculture and Natural Resources, the Philippines; Dr. Paulino J. Garcia, Chairman, National Science Development Board, the Philippines; Dr. Forrest F. Hill, Vice President, the Ford Foundation; Dr. Hitoshi Kihara, Director, National Institute of Genetics, Japan; Dr. P. C. Ma, Dean, College of Agriculture, National Taiwan University; Dr. Vicente G. Sinco, President, University of the Philippines; and Dr. Robert F. Chandler, Jr., Director of the Institute.

The Institute's research laboratories will be centered in a single-story, air-conditioned building which, when completed in 1962, will provide separate areas for studies in plant breeding, genetics and taxonomy, chemistry and biochemistry, agronomy, soil chemistry and soil physics, plant physiology, plant pathology and entomology, agricultural economics, and statistics. There will also be several special-purpose research laboratories, a photographic laboratory, and offices for the scientific staff and trainees.

A unique feature of the Institute will be its facility for studies of plant growth under conditions of controlled and semi-controlled environment. The specialized building will contain four greenhouses, laboratories, and six chambers in which temperature and day length can be controlled. It will be possible to grow plants in full sunlight during the day and, at the same time, to regulate daytime root temperatures by means of water baths surrounding the plant containers. By rolling the plants into the controlled-temperature chambers in late afternoon, day length and above- and below-ground night temperatures also can be maintained at desired levels.

About 200 acres of land are being developed for field research purposes. By mid-1961, construction of roads, bridges, and fences was well under way and land was being leveled to provide experimental paddy fields varying from one-eighth to one-half acre in size. The paddies can be individually irrigated or drained at any time by means of an underground concrete pipe supply system and surface drainage ditches. Water depth in the paddies will not exceed 2 inches, except by intent for experimental purposes.

Facilities related to operations of the experimental farm are housed in the service building, a structure 400 feet long by 180 feet wide, which was completed in the spring of 1961. This building contains the agricultural engineering offices and experimental laboratory, seed dryer, seed processing laboratory, controlled-temperature seed storage areas, emergency power plant, vehicle service station, shops, areas for storage of farm equipment and supplies of all kinds, and offices for the farm superintendent and his staff. A unique feature of the service building is its 60 by 400-foot central bay, which is designed to provide ample space for many types of indoor work, from equipment repair to threshing operations, during the many rainy days which must be expected in the humid tropics.

Trainees will begin arriving in 1962 to study and work under the guidance of the senior scientists of the Institute for periods from a few months to two years. A three-story dormitory containing 30 rooms, each room to house two trainees, is scheduled for completion in late 1961. A first-floor extension of this building will contain a cafeteria, private dining rooms, and a lounge. These facilities will provide complete accommodations for trainees a few steps from their laboratories and desks.

During 1961, the assembling of the Institute's library was begun in New York. The collection, expected to total eventually at least 100,000 volumes, will be placed in the library section of the administration building. This sizable building will house, in addition to the necessary administrative offices and the library, offices for visiting scientists, an exhibit hall, seminar rooms, and a 200-seat auditorium. The two latter facilities will be used for lectures, forums, various discussion groups, and occasional international conferences.

Accommodations for 23 staff families, and a guest house for visiting scientists and others interested in the Institute's activities, are under construction on a nearby hillside above the campus of the College of Agriculture of the University of the Philippines. Temporary office quarters were set up in the service building pending the completion of the administration and laboratory buildings.

Candidates from several Asian nations were interviewed during 1961 for the senior scientific positions. Several young but thoroughly capable and well-trained Asian scientists have accepted positions with the Institute and agreed to arrive before the end of the year, so that the research and training programs can be initiated early in 1962.

FELLOWSHIPS, SCHOLARSHIPS, AND TRAINING AWARDS

AID TO RESEARCH AND TEACHING

PUBLICATIONS 1960–1961

Fellowships, Scholarships, and Training Awards

Active from July 1, 1960, to June 30, 1961

The Fellowship and Scholarship Program in the Agricultural Sciences requires a budget of more than one million dollars annually. There were 275 fellowships, scholarships, and training awards active during the year ending June 30, 1961, with representation from faculties of agriculture and veterinary science, research institutes, and government agencies in 26 countries.

Major emphasis continues to be given to the training of young Latin American scientists, especially those associated directly or indirectly with the operating programs. The total number of active appointments from Latin America during the year was 164, including 50 from Mexico, 25 from Colombia, and 12 from Chile.

The Asian program is also at about the same level as in previous years. There were a total of 81 appointees from this part of the world. India with 33 appointees, Japan with 28, and the Philippines with 25 reflect the Foundation's efforts to build on institutional strength in those countries, both in the field of postgraduate agricultural education and in agricultural research.

The number of Polish appointees was relatively high, with 28 outstanding young scientists studying in the United States or Western Europe between July 1, 1960, and June 30, 1961. This raises to 72 the total number of Polish scientists receiving fellowship grants in the Agricultural Sciences under the Foundation's emergency program since it was initiated in 1957. There will be a continuing interest in Poland in future years, particularly in following the scientific output of returned fellows. New appointments will, however, be made available at a considerably reduced annual rate.

A new trend in the Agricultural Sciences training program is reflected in the three African appointments. It is hoped that regular officer visits to the countries south of the Sahara will develop useful opportunities for support of postgraduate training of increasing numbers of young Africans.

An interesting note is found in the list of Asian scholars which includes five South Vietnamese, all of whom completed their undergraduate training at the College of Agriculture of the University of the Philippines. This College has had Foundation support over a period of several years as a center of undergraduate training for Southeast Asians.

Subject matter emphasis in making candidate selection has been on those phases of the agricultural sciences which are quite directly related to improvement of basic food crops. Subject matter areas are listed below in the order of the number of appointments:

Genetics and Plant Breeding	52
Soil Science	37
Plant Pathology	25
Agronomy	21
Veterinary Science	21
Entomology	19
Economics and Rural Life	17
Animal Nutrition and Physiology	11
Plant Physiology	9
Chemistry	9
Agricultural Engineering	5
Home Economics	5
Horticulture	5
Poultry Husbandry and Science	5
Statistics	5
Engineering	4
Animal Science	3
Forestry	3
Genetics and Animal Breeding	3
Library Science	3
Marine Resources	3
Botany	2
Dairy Husbandry	2
Dairy Science	1
Fisheries	1
Food Technology	1
Microbiology	1
Nematology	1
Zoology	1

Fellows and scholars studied at 46 different institutions in the United States and at 18 abroad. Following is a list of the major institutions in the order of the number of Foundation appointees at each:

University of California	35
Davis—22	
Berkeley—12	
Riverside—1	
Cornell University	34
University of Wisconsin	29
University of Minnesota	18
Iowa State University	15
North Carolina State College	15
Michigan State University	9
Utah State University	7
Texas Agricultural and Mechanical College	5
Oregon State College	5
Purdue University	5
Colorado State University	5
University of Nebraska	5
Louisiana State University	4
Oklahoma State University	4
Pennsylvania State University	3
Rutgers University	3
University of Illinois	3

The appointees in active status during the year ending June 30, 1961, are listed in the following pages by country and sponsoring institution. The name of the Fellow (F), Scholar (S), or Training Awardee (TA) is followed by the general area of study and finally by the name of the study post.

ARGENTINA

National Institute of Agricultural and Livestock Technology, Buenos Aires

- s **Arias, Hipolito Leandro,** Economics & Rural Life, Cornell University
- TA **Chabrillon, Alberto Luis,** Genetics & Plant Breeding, Mexican Agricultural Program
- s **Ernie, Enrique René,** Soil Science, Mexican Agricultural Program
- s **Induni, César Juan,** Plant Pathology, University of Wisconsin
- s **López Saubidet, Carlos Alfredo,** Genetics & Animal Breeding, Iowa State University
- s **Rossi, Juan Carlos,** Genetics & Plant Breeding, Mexican Agricultural Program
- s **Tiranti, Iván Nicolás,** Genetics & Plant Breeding, Texas Agricultural and Mechanical College
- TA **Vergani, Aldo Raúl,** Entomology, University of California, Riverside
- s **Von Der Pahlen, Alejo Wendt P. R.,** Plant Pathology, University of California, Davis

AUSTRALIA

Commonwealth Scientific and Industrial Research Organization, Adelaide

- F **Tiller, Kevin George,** Soil Science, Cornell University

Commonwealth Scientific and Industrial Research Organization, Canberra

- F **Appleby, Cyril A.,** Chemistry, Brandeis University

University of Sydney

- F **Crofts, Frank Clement,** Agronomy, Oregon State College

BOLIVIA

University of San Simón, "La Tamborada" Agricultural Experiment Station, Cochabamba

- s **Ayala Zambrana, Jorge,** Poultry Husbandry, Mexican Agricultural Program

BRAZIL

Association for Credit and Rural Assistance, Belo Horizonte, Minas Gerais

- s **Vasconcellos, Federico Cotta de,** Economics & Rural Life, Mexican Agricultural Program

Institute of Agronomy of the State of São Paulo, Campinas

- s **Da Silva, Darcy Martins,** Chemistry, University of California, Berkeley
- s **Miranda, Luis Torres,** Genetics & Plant Breeding, Mexican Agricultural Program
- s **Monaco, Lourival Carmo,** Genetics & Plant Breeding, University of California, Davis

Desiderio Finamor Institute of Veterinary Research, Guaiba, Rio Grande do Sul

- F **Mancuso, Pedro Carlos,** Veterinary Science, University of California, Davis

Institute of Biology, São Paulo

- s **Elias, Rames,** Entomology, Mexican Agricultural Program

Ministry of Agriculture

INSTITUTE OF ANIMAL BIOLOGY

- s **Dobereiner, Jürgen,** Veterinary Science, University of Wisconsin

NATIONAL CENTER FOR AGRICULTURAL RESEARCH AND EDUCATION

- s **Braun, Walter Augusto Gross,** Soil Science, University of California, Davis

UNIVERSITY OF MINAS GERAIS, SCHOOL OF VETERINARY SCIENCE, BELO HORIZONTE

- S **Bernis, Walter Octaviano,** Veterinary Science, Texas Agricultural and Mechanical College
- S **Couto, Edalmo Souza,** Veterinary Science, Texas Agricultural and Mechanical College

UNIVERSITY OF RIO GRANDE DO SUL, SCHOOL OF AGRONOMY AND VETERINARY SCIENCE, PÔRTO ALEGRE

- S **Oliveira, Fernando Correa,** Economics & Rural Life, University of Wisconsin
- S **Ramos, Paulo Dias de Castro,** Agricultural Engineering, University of California, Davis

UNIVERSITY OF SÃO PAULO, SUPERIOR SCHOOL OF AGRICULTURE "LUIZ DE QUEIROZ," PIRACICABA

- S **Dias, Domiciano Pereira de Souza,** Entomology, University of Kansas
- F **Malavolta, Euripedes,** Chemistry, University of California, Berkeley
- F **Ranzani, Guido,** Soil Science, Cornell University

CEYLON

DEPARTMENT OF AGRICULTURE, PERADENIYA

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- S **de Silva, Mervyn Dominic,** Entomology, University of California, Berkeley
- F **Jayaweera, Don Martin Arthur,** Botany, Harvard University
- S **Marks, Geoffrey Charles,** Plant Pathology, University of Wisconsin
- F **Sivarajasingham, Sivasupramaniam,** Soil Science, Cornell University

DRY ZONE RESEARCH STATION, MAHA

- S **Alles, Wajiraransi Saddhani,** Soil Science, University of Michigan and Ohio State University

CHILE

CATHOLIC UNIVERSITY OF CHILE, SANTIAGO

- S **Norero, Aldo,** Soil Science, Oregon State University
- S **Trivelli Gandal, Osvaldo,** Genetic & Plant Breeding, Mexican Agricultural Program
- S **Yopo Paiva, Boris,** Genetics & Animal Breeding, Cornell University

MINISTRY OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL PRODUCTION AND FISHERIES

- F **Cortázar Sagarmínaga, René,** Genetics & Plant Breeding, University of Minnesota

DEPARTMENT OF AGRICULTURAL RESEARCH

- S **López Villanueva, Hernán,** Plant Physiology, Oregon State University
- S **Valdivia Bugueno, Vital,** Genetics & Plant Breeding, University of Minnesota
- S **Violic Martinovic, Alejandro,** Genetics & Plant Breeding, University of Minnesota

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SCHOOL OF AGRICULTURE

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- F **Mancilla Cabanas, Rafael,** Veterinary Science, University of Texas, Galveston

UNIVERSITY OF CONCEPCIÓN, CONCEPCIÓN

- s **Artigas Coch, Jorge,** Entomology, Ohio State University

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- F **Camacho, Luis H.,** Genetics & Plant Breeding, North Carolina State College
- s **Díaz Rodríguez, Genaro,** Soil Science, University of Georgia
- s **Duarte, Rodrigo,** Genetics & Plant Breeding, Michigan State University
- s **Echeverri E., Silvio,** Agronomy, Oregon State College
- s **Galvez Enriquez, Guillermo Edmundo,** Plant Pathology, University of Nebraska
- F **García Brand, José,** Economics & Rural Life, University of Wisconsin
- TA **León Sarmiento, Luis Alfredo,** Soil Science, North Carolina State College
- s **López Rubio, Hernán,** Veterinary Science, University of Minnesota
- s **Lujan Claure, Lauro,** Horticulture, Cornell University
- s **Marin Morales, José Gildardo,** Soil Science, North Carolina State College
- s **Oñoro-Cerra, Pedro Raúl,** Statistics, North Carolina State College
- s **Quintero Pinto, Jorge,** Engineering, University of California, Davis
- s **Ramírez Castaño, Amalia,** Library Science, Rutgers University
- F **Ramírez Estrada, Ricardo,** Genetics & Plant Breeding, North Carolina State College
- s **Ramírez Ospina, Rodrigo,** Agronomy, North Carolina State College
- s **Rosero Morán, Manuel Jesús,** Genetics & Plant Breeding, University of Minnesota
- s **Sohm Kuhne, Oscar Dieter,** Genetics & Plant Breeding, Louisiana State University
- s **Van Cotthem M., Luis Carlos,** Animal Physiology, Oklahoma State University
- F **Zapata Balcázar, José Mario,** Genetics & Plant Breeding, North Dakota Agricultural College

NATIONAL UNIVERSITY, COLLEGE OF AGRICULTURE, MEDELLÍN

- F **Ospina, Oscar,** Soil Science, University of California, Berkeley
- TA **Puerta, Consuelo,** Library Science, Rutgers University

UNIVERSITY OF CALDAS, MANIZALES

- s **Marín Villegas, Jaime,** Agricultural Engineering, University of California, Davis
- s **Mejia, Giraldo Germán,** Soil Science, Purdue University
- s **Muñoz Dávila, Alvaro,** Veterinary Science, Tulane University

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Inter-American Institute of Agricultural Sciences, Turrialba

- F **Carballo Quiros, Alfredo,** Genetics & Plant Breeding, North Carolina State College
- F **Díaz Bordenave, Juan Enrique,** Economics & Rural Life, Michigan State University
- S **Jiménez Saenz, Eduardo,** Plant Physiology, Michigan State University

Ministry of Agriculture and Industries, San José

- S **Coto Monge, Alvaro,** Plant Pathology, Pennsylvania State University
- S **Rodriguez, Ricardo A.,** Plant Pathology, University of Minnesota

ECUADOR

Central University, Quito

- S **Albornoz P., Guillermo,** Genetics & Plant Breeding, Colombian Agricultural Program
- S **Luzuriaga F., Gonzalo,** Genetics & Plant Breeding, Colombian Agricultural Program

Ministry of Development, National Wheat Commission, Izobamba

- S **Larrea Herrera, Pablo Enrique,** Genetics & Plant Breeding, Mexican Agricultural Program

GUATEMALA

National Agricultural and Livestock Institute, La Aurora

- S **Sosa Sandoval, Oscar Nery,** Plant Pathology, University of Minnesota

INDIA

Agricultural College and Research Institute, Coimbatore

- S **Seshadri, A. R.,** Nematology, University of California, Berkeley

Central Rice Research Institute, Cuttack

- S **Chaudhry, Mahabir Singh,** Agronomy, Ohio State University
- F **Patnaik, Satchidanand,** Soil Science, University of California, Davis

Central Tobacco Research Institute, Rajahmundry

- F **Radhakrishnamurty, Bhyravabhotla,** Genetics & Plant Breeding, Cornell University

Coordinated Maize Breeding Scheme, Amberpet, Hyderabad

- S **Sankara Rao, Mandava,** Genetics & Plant Breeding, University of Nebraska

Government of Andhra Pradesh, Department of Agriculture, Hyderabad

- S **Narayan, Kishen,** Genetics & Plant Breeding, Texas Agricultural and Mechanical College
- S **Pillay, Trichinopoly Nataraj Dathathry,** Horticulture, Cornell University
- S **Ramana Murthy, Gundugurthy Venkata,** Genetics & Plant Breeding, University of California, Davis
- S **Venkataswamy, Tady,** Genetics & Plant Breeding, Louisiana State University

Government of Bihar, Department of Agriculture, Bhagalpur

- F **Jha, Kali Kant,** Soil Science, University of Wisconsin
- F **Jha, Parmeshwari Prasad,** Soil Science, Cornell University

GOVERNMENT OF HIMACHAL PRADESH, DEPARTMENT OF AGRICULTURE, SIMLA
- S **Thakur, Parkash Chand,** Soil Science, University of California, Berkeley

GOVERNMENT OF MADHYA PRADESH, AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE, GWALIOR
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- S **Jethmalani, Shampal Chuharmal,** Agronomy, Utah State University
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- S **Solanki, Sadhu S. S.,** Agronomy, University of Wisconsin
- F **Tamboli, Prabhakar Mahadeo,** Soil Science, Iowa State University
- S **Verma, Gopal Prasad,** Soil Science, Iowa State University

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GOVERNMENT OF WEST BENGAL, DEPARTMENT OF AGRICULTURE, CALCUTTA
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- F **Das, Chittaranjan,** Plant Pathology, Oregon State College
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- F **Roy, Narendra Nath,** Genetics & Plant Breeding, Cornell University

HOME SCIENCE WING, RAJENDRANAGAR, HYDERABAD
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INDIAN AGRICULTURAL PROGRAM OF THE ROCKEFELLER FOUNDATION, NEW DELHI
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INSTITUTE OF AGRICULTURE, ANAND
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- F **Patel, Kanubhai Arvindbhai,** Genetics & Plant Breeding, North Carolina State College
- F **Patel, Ramjibhai Madhavbhai,** Statistics, North Carolina State College
- F **Shah, Champaklal Bhogilal,** Plant Physiology, University of California, Davis

KARNATAK UNIVERSITY, MYSORE
- S **Patil, Siddangouda Venkangouda,** Agronomy, Utah State University

MINISTRY OF FOOD AND AGRICULTURE, NEW DELHI
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- S **Sharma, Jagdish Chandra,** Economics & Rural Life, Cornell University

RAJASTHAN COLLEGE OF AGRICULTURE, UDAIPUR
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INDONESIA

UNIVERSITY OF INDONESIA, BOGOR

FACULTY OF AGRICULTURE
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FACULTY OF VETERINARY SCIENCE
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- S **Soekotjo, Wirasmono,** Veterinary Science, Michigan State University

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HEBREW UNIVERSITY, JERUSALEM
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JAPAN

FUKUSHIMA LIVESTOCK BREEDING STATION
- TA **Ishihara, Shuji,** Agronomy, Oregon State University

HOKKAIDO NATIONAL AGRICULTURAL EXPERIMENT STATION, SAPPORO
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- F **Sakai, Hiroshi,** Soil Science, North Carolina State College

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- S **Kitano, Kiyomitsu,** Marine Resources, University of Washington

HOKKAIDO UNIVERSITY
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  - F **Hosokawa, Sadaji,** Genetics & Plant Breeding, Colorado State University
  - F **Ishikawa, Yoshinori,** Chemistry, University of Vermont
  - F **Okazawa, Yozo,** Plant Physiology, Colorado State University
- FACULTY OF FISHERIES
  - F **Nishizawa, Satoshi,** Marine Resources, Yale University

KYOTO UNIVERSITY, FACULTY OF AGRICULTURE
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- S **Maki, Yoshisuke,** Agronomy, University of Wisconsin
- S **Suzuki, Akira,** Soil Science, Michigan State University

KYUSHU UNIVERSITY, FACULTY OF AGRICULTURE, FUKUOKA
- S **Fujihara, Teruo,** Engineering, California Institute of Technology
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- F **Yamada, Yoshio,** Soil Science, Rothamsted Experiment Station, Harpenden, England

MINISTRY OF AGRICULTURE AND FORESTRY, TOKYO
- S **Abiko, Chie,** Home Economics, Michigan State University

NAGOYA UNIVERSITY, FACULTY OF AGRICULTURE, ANJO
- F **Ashida, Kiyoshi,** Animal Nutrition, University of Wisconsin
- F **Kuyama, Shimpei,** Microbiology, Rutgers University
- F **Yokoyama, Akira,** Animal Physiology, University of Reading, England

NATIONAL INSTITUTE OF AGRICULTURAL SCIENCES, CHIBA-CITY
- F **Hachinohe, Yoshio,** Entomology, Iowa State University
- F **Namioka, Shigeo,** Veterinary Science, Cornell University

NATIONAL INSTITUTE OF ANIMAL HEALTH, TOKYO
- TA **Yanagawa, Ryo,** Veterinary Science, University of Wisconsin

NATIONAL INSTITUTE OF GENETICS, MISHIMA
- F **Iyama, Shin-ya,** Genetics & Plant Breeding, University of Minnesota

OKAYAMA UNIVERSITY, OHARA INSTITUTE FOR AGRICULTURAL BIOLOGY, KURASHIKI
- F **Hiura, Unji,** Plant Pathology, University of Minnesota

TOHOKU UNIVERSITY, FACULTY OF AGRICULTURE, SENDAI
- F **Adachi, Susumu,** Dairy Science, Pennsylvania State University

TOKYO UNIVERSITY, FACULTY OF AGRICULTURE
- S **Shimaji, Ken,** Botany, Yale University
- F **Usui, Kazuya,** Animal Nutrition, Cornell University

MEXICO

Institute of Technology and Higher Studies, Monterrey

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- F **Leal Díaz, Jaime,** Soil Science, University of California, Davis
- S **Morales Ramos, Daniel,** Soil Science, Cornell University
- F **Rivera Camarena, Jorge Enrique,** Plant Pathology, University of Florida

Ministry of Agriculture and Livestock, National Institute of Agricultural Research*

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- F **Aguilera Amezcua, Augusto,** Animal Science, University of Illinois
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- S **Bixler, Edsel George,** Poultry Science, University of Maryland
- F **Brauer Herrera, Oscar,** Genetics & Plant Breeding, University of Göttingen, Germany
- S **Campos Vela, Armando, VI,** Plant Pathology, University of Wisconsin
- F **Cárdenas Ramos, Francisco,** Genetics & Plant Breeding, Michigan State University
- S **Carrillo Sánchez, José Luis,** Entomology, Oregon State College
- S **Casas D., Eduardo,** Genetics & Plant Breeding, North Carolina State College
- F **Cervantes Romo, Javier,** Genetics & Plant Breeding, University of Wisconsin
- S **Chan, Ricardo Moreno,** Poultry Science, Michigan State University
- F **Crispín Medina, Alfonso,** Plant Pathology, University of California, Davis
- S **Cuca García, Manuel,** Poultry Science, Washington State University
- S **Dávila Guzmán, Edmundo,** Plant Pathology, University of Minnesota
- S **de las Casas Aguirre, Ernesto,** Entomology, University of Minnesota
- S **Delgado Sánchez, Santiago,** Plant Pathology, University of Minnesota
- F **Galindo Alonso, Jorge,** Plant Pathology, University of California, Berkeley
- F **García Sánchez, Alfredo,** Agronomy, Kansas State University
- F **González Alanis, Martín H.,** Agronomy, Utah State University
- S **Hernández Bravo, Guillermo,** Horticulture, Pennsylvania State University
- S **Jiménez Sánchez, Leobardo,** Economics & Rural Life, University of Wisconsin
- S **López Frias, Luis César,** Plant Pathology, University of Minnesota
- S **Martínez, Gregorio,** Economics & Rural Life, University of Wisconsin
- F **Martínez Salazar, Eugenio,** Plant Pathology, University of Wisconsin
- S **Miranda Colín, Salvador,** Genetics & Plant Breeding, University of California, Davis
- F **Muñoz Garza, Juan Manuel,** Agronomy, University of Nebraska
- S **Navarro Franco, Manuel,** Agronomy, University of Wisconsin
- F **Nieto Hatem, Jorge,** Plant Physiology, Iowa State University
- S **Núñez Escobar, Roberto,** Soil Science, University of California, Davis
- F **Ortega Castro, Jacobo,** Plant Pathology, University of Minnesota
- F **Pacheco Mendívil, Francisco,** Entomology, University of Illinois
- S **Padilla Aranda, Rafael,** Entomology, University of Massachusetts
- F **Patiño Mendez, Graciano,** Plant Pathology, University of California, Davis
- S **Pérez Ugalde, Gelacio,** Genetics & Plant Breeding, University of Wisconsin
- S **Ramírez Paz, Félix,** Soil Science, Purdue University
- S **Romero Cova, Sebastián,** Plant Pathology, West Virginia University

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- F **Sifuentes Aguilar, Juan Antonio,** Entomology, Kansas State University
- S **Silos, José S.,** Economics & Rural Life, Cornell University
- S **Velasco, Marcial,** Animal Physiology, Oklahoma State University
- S **Wing Martínez, Marco Antonio,** Genetics & Plant Breeding, University of Nebraska

NATIONAL SCHOOL OF AGRICULTURE, CHAPINGO

- F **Chena González, Rodolfo,** Economics & Rural Life, Cornell University
- S **Guerrero S., Daniel,** Plant Physiology, Iowa State University
- F **Teliz Ortiz, Moisés,** Plant Pathology, University of Wisconsin
- S **Vázquez González, José Trinidad,** Entomology, University of California, Davis

NATIONAL UNIVERSITY, FACULTY OF VETERINARY SCIENCE, MEXICO CITY

- S **Aluja, Aline Schuneman-Hofer de,** Veterinary Science, University of Pennsylvania

UNIVERSITY OF SONORA, HERMOSILLO

- S **Hidalgo-Arrecillas, Raúl,** Poultry Husbandry, Texas Agricultural and Mechanical College

NATIONAL REPUBLIC OF CHINA, TAIWAN

CHINESE-AMERICAN JOINT COMMISSION ON RURAL RECONSTRUCTION, TAIPEI

- F **Lee, Robert Chung Tao,** Veterinary Science, Cornell University

NICARAGUA

MINISTRY OF AGRICULTURE AND LIVESTOCK, MANAGUA

- S **Lizárraga Herrera, Joaquín Héctor,** Soil Science, North Carolina State College

NIGERIA

UNIVERSITY COLLEGE, IBADAN

- F **Hill, Desmond Hayward,** Animal Physiology, Louisiana State University and University of São Paulo, Brazil

PAKISTAN

MINISTRY OF FOOD AND AGRICULTURE, KARACHI

- F **Hassan, Muhammad Amjad,** Soil Science, University of Illinois

PERU

AGRARIAN UNIVERSITY, LA MOLINA, LIMA

- F **Grobman, Alexander,** Genetics & Plant Breeding, Harvard University
- S **Paulette del Campo, Miguel,** Agronomy, University of Nebraska
- S **Salhuana MacKee, Wilfredo Sergio,** Statistics, North Carolina State College

MINISTRY OF AGRICULTURE, COOPERATIVE PROGRAM OF AGRICULTURAL AND LIVESTOCK RESEARCH

- S **Christiansen González, Jorge,** Genetics & Plant Breeding, Mexican Agricultural Program
- S **Romero Loli, Marino,** Genetics & Plant Breeding, Mexican Agricultural Program

s **Dongo Denegri, Segundo,** Plant Pathology, Mexican Agricultural Program
s **Sánchez Campos, Hugo Eduardo,** Genetics & Plant Breeding, Mexican Agricultural Program

The National University of San Marcos, Faculty of Veterinary Science, Lima
s **Copaira Beltrán, Marcos,** Veterinary Science, University of Minnesota
f **Lombardi Lombardi, Max,** Veterinary Science, Cornell University

PHILIPPINES

Bureau of Plant Industry, Manila
s **Andes, Bienvenido C.,** Agricultural Engineering, Oklahoma State University

Bureau of Public Schools, Manila
f **Quirolgico, Delfín G.,** Economics & Rural Life, Stanford University

Central Luzon Agricultural College, Nueva Ecija
f **Abella y Aguilar, Pedro,** Agronomy, University of Florida
f **Juliano, Jorge Patriarca,** Plant Pathology, University of California, Berkeley

Forest Products Research Institute, Laguna
s **Avanzado, Norma Arlac Abigania,** Forestry, University of Wisconsin

International Rice Research Institute, Philippines*
ta **Manalo, Lina D.,** Library Science, U. S. Department of Agriculture Library, Washington, D.C., and Columbia University

Mindanao Agricultural College, Bukidnon
ta **Pepito, Narciso N.,** Animal Physiology, Oklahoma State University
f **Zablan, Florendo Flores,** Economics & Rural Life, Cornell University

Philippine Atomic Energy Commission, Manila
f **Valencia, Iluminado G.,** Soil Science, University of Wisconsin

University of the Philippines

college of agriculture
f **Alfonso, Pablo J.,** Zoology, Colorado State University
s **Bernardo, Fernando Apelo,** Genetics & Plant Breeding, University of California, Davis
f **Bustrillos, Nena Rola,** Home Economics, Michigan State University
f **Calora, Feliciano Banaag,** Entomology, Cornell University
f **Castillo, Leopoldo S.,** Dairy Husbandry, Cornell University
f **de Guzman, Emerita V.,** Plant Physiology, Cornell University
s **Divinagracia, Gil G.,** Plant Pathology, University of California, Davis
f **Gabriel, Bernardo Panuncialman,** Entomology, University of California, Berkeley
f **Lantican, Domingo M.,** Forestry, New York College of Forestry
f **Lantican, Ricardo Manzo,** Genetics & Plant Breeding, Iowa State University
ta **Oñate, Luz U. (Mrs. Burton T.),** Home Economics, Iowa State University
f **San Juan, Mario O.,** Plant Pathology, University of Wisconsin
f **Sison, (Mrs.) Obdulia E. Fronda,** Economics & Rural Life, Cornell University
f **Vega, Marcos R.,** Plant Physiology, North Carolina State College
f **Yniguez, Amador D'Bayan,** Statistics, North Carolina State College

college of liberal arts
f **Juliano, Rogelio Ochoa,** Marine Resources, University of Michigan

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POLAND

AGRICULTURAL COLLEGE, LUBLIN

F **Bezubik, Bernard,** Veterinary Science, U. S. Department of Agriculture, Beltsville, Maryland

F **Oktaba, Wiktor,** Statistics, Iowa State University

F **Pinkiewicz, Edward,** Veterinary Science, Clinic for Internal Diseases of Animals, Vienna, Austria

F **Prost, Edmund,** Veterinary Science, Federal Research Institute for Animal Husbandry, Kulmbach, Germany

S **Strzelczyk, Edmund,** Soil Science, Microbiology Research Institute, Ottawa, Canada

CENTRAL SCHOOL OF RURAL ECONOMICS, WARSAW

F **Dluzewski, Mieczyslaw,** Veterinary Science, National Institute for Research in Dairying, Reading, England

COLLEGE OF AGRICULTURE, CRACOW

F **Samotus, Boguslaw,** Chemistry, U. S. Department of Agriculture, Albany, California, and University of Cambridge, England

COLLEGE OF AGRICULTURE, POZNAN

F **Glaser, Tadeusz,** Horticulture, Institute of Phytopathological Research, Wageningen, Netherlands

F **Szymanski, Stefan,** Plant Physiology, Göttingen University, Germany

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F **Starck, Jan Roman,** Soil Science, University of Wisconsin

MINISTRY OF AGRICULTURE, EXPERIMENTAL FARM FOR ANIMAL BREEDING, GRODZIEC

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MINISTRY OF AGRICULTURE, INSTITUTE OF AGRICULTURE, PULAWY

S **Doruchowski, Roch Wlodzimierz,** Genetics & Plant Breeding, University of Wisconsin

MINISTRY OF AGRICULTURE, INSTITUTE OF INLAND WATER FISHERIES, OLSZTYN-KORTOWO

F **Patalas, Kazimierz,** Fisheries, University of British Columbia, Vancouver, Canada

MINISTRY OF AGRICULTURE, INSTITUTE OF PLANT BREEDING AND ACCLIMATIZATION, PULAWY

F **Ruszkowski, Marek,** Genetics & Plant Breeding, University of Minnesota

F **Blaim, Kazimierz,** Chemistry, University of Zurich, Switzerland

MINISTRY OF AGRICULTURE, INSTITUTE OF SOIL SCIENCE AND PLANT CULTIVATION, PULAWY

S **Wrobel, Tadeusz,** Soil Science, University of Wisconsin

MINISTRY OF AGRICULTURE, PLANT BREEDING INSTITUTE, BYDGOSZCZ

S **Pawelska, Krystyna,** Entomology, Rothamsted Experimental Station, Harpenden, England

F **Szota, Zdzislaw,** Genetics & Plant Breeding, Colorado State University

MINISTRY OF AGRICULTURE, PLANT BREEDING INSTITUTE, POLANOWICE

F **Jassem, Marek Avrelian,** Genetics & Plant Breeding, U. S. Department of Agriculture, Salt Lake City

MINISTRY OF AGRICULTURE, VETERINARY RESEARCH INSTITUTE, PULAWY

F **Grundboeck, Marian,** Veterinary Science, University of Wisconsin

F **Truszczynski, Marian,** Veterinary Science, Boston University

F **Zebrowski, Leon,** Veterinary Science, University of Toronto, Canada

Polish Academy of Sciences, Skierniewice

s **Chmielewski, Tadeusz,** Genetics & Plant Breeding, University of California, Davis

Polish Academy of Sciences, Warsaw

F **Poczopko, Piotr,** Animal Physiology, New York University

Polytechnic Institute of Mechanization and Electrification of Agriculture, Warsaw

F **Bernacki, Henryk,** Agricultural Engineering, Institute for Fundamental Research in Agricultural Engineering, Volkenrode, Germany

F **Pabis, Stanislaw,** Agricultural Engineering, University of California, Davis

State Institute of Hygiene, Warsaw

F **Bartnik, Jan Marian,** Chemistry, University of Wisconsin

F **Zaleski, Jan Henryk,** Food Technology, Massachusetts Institute of Technology

SUDAN

University of Khartoum

s **Osman Mousa, Hussein Elsayed,** Genetics & Animal Breeding, University of Edinburgh, Scotland

THAILAND

Kasetsart University, College of Agriculture, Bangkok

F **Chutima, (Mrs.) Krisna,** Chemistry, Purdue University

s **Kanchanomai, Prachern,** Agronomy, Louisiana State University

s **Kasetsuwan, Suwan,** Poultry Husbandry, Utah State University

F **Khatikarn, Bunjird,** Horticulture, Utah State University

TA **Sitachitt, Prasertsri Dee-Ananta,** Home Economics, Utah State University

Royal Irrigation Department, Bangkok

s **Poolsup, Maitri,** Engineering, Utah State University

UGANDA

Department of Veterinary Services and Animal Industry, Kampala

s **Thornton, David Dillon,** Forestry, University of California, Berkeley

SOUTH VIETNAM

Ministry of Agriculture, Saigon

s **Minh, Duong Van,** Engineering, Cornell University

s **Quan, Cao,** Economics & Rural Life, Cornell University

s **Quyen, Ngo Van,** Entomology, Cornell University

s **Tri, Bui Huu,** Soil Science, Cornell University

s **Van, Nguyen Hoai,** Soil Science, Cornell University

Aid to Research and Teaching

UNITED STATES

Dr. H. S. Swingle, fish culturist and professor of fisheries management, Auburn University, Alabama: to assess research on fish culture and fisheries management for the Ministry of Food and Agriculture, New Delhi, India; $5,450.

Clemson Agricultural College, South Carolina: research equipment for the Department of Botany and Bacteriology; $5,000.

Conservation Foundation, New York: an ecological survey of the Mara-Mau area of Kenya; $7,500.

Cornell University, Ithaca, New York: a special orientation program for foreign graduate students, to be developed by the College of Agriculture; $10,000.

Duke University, Durham, North Carolina: research on forest hydrology, at the School of Forestry; $100,000.

Entomological Society of America, College Park, Maryland: to invite Dr. J. de Wilde, director, Entomological Laboratory, Agricultural University, Wageningen, Netherlands, to participate in the society's annual meetings in November, 1961, and to visit centers of entomological research in the United States; $1,600.

Iowa State University of Science and Technology, Ames: research on the role of accessory (B) chromosomes in maize; $10,000.

Louisiana State University, Baton Rouge: research on genetic and cytogenetic relationships in rice, by the Department of Agronomy; $36,000.

National Academy of Sciences—National Research Council, Washington, D.C.: an ecological study of the plains wildlife of East Africa; $3,000.

North Carolina State College, Raleigh: development of research and graduate training in maize genetics and breeding; $125,000.

Ohio Agricultural Experiment Station, Wooster:

Laboratory equipment, supplies, and research expenses; $9,500;

Dr. Leonard J. Alexander, professor of plant pathology; to visit centers of research in plant pathology in Europe; $6,000.

Ohio State University, Columbus: research on the fungal synthesis of microbial protein, under the direction of Dr. W. D. Gray, Department of Botany and Plant Pathology, College of Agriculture and Home Economics; $10,000.

Oklahoma State University, Stillwater:

Support of the research and teaching activities of the university's Agricultural Education Program in Ethiopia; $10,000;

A wheat rust survey to be conducted by Dr. Harry C. Young, Department of Plant Pathology; $8,390.

Phillips Academy, Robert S. Peabody Foundation for Archaeology, Andover, Massachusetts: research on the origin and domestication of cultivated plant species in the region surrounding Tehuacán, Mexico; $10,000.

Texas Research Foundation, Renner: to meet expenses connected with research on the genus *Solanum;* $7,750.

United States Department of Agriculture, Washington, D.C.:

Dr. C. S. Holton, pathologist, Regional Smut Research Laboratory, Division of Plant Pathology, Agricultural Experiment Station, Washington State University, Pullman, and currently a visiting investigator at the Cryptogamic Laboratory, Pavia, Italy; to visit centers of research on cereal smuts in Europe; $1,725;

Graduate School; a course in science reference and bibliography for agricultural librarians from other countries; $680.

University of Alaska, College: studies of grass and legume species, by the Alaska Agricultural Experiment Station in cooperation with the University of Wisconsin Agricultural Experiment Station; $39,000.

University of California:

Davis:

To plan a program of international service in agriculture; $10,000;

Dr. Emil M. Mrak, chancellor; to visit centers of food research and processing in Japan; $4,600.

Riverside:

Dr. Homer D. Chapman, chairman, Department of Soils and Plant Nutrition; to visit centers of research on citrus plant nutrition in India; $4,925.

University of Minnesota, St. Paul: research on chemical mutagenesis, chiefly at the University of Edinburgh, by Dr. Leon A. Snyder, associate professor of agronomy and plant genetics, Department of Agronomy, Institute of Agriculture; $7,500.

University of Wisconsin, Madison: study of normal and abnormal growth and the metabolism of plant tissue, by the Plant Pathology Department; $12,000.

Virginia Polytechnic Institute, Blacksburg: to equip a new classroom and laboratory building for the Department of Biochemistry and Nutrition; $7,500.

World Health Organization Pan American Sanitary Bureau, Washington, D.C.: research on the chemical composition and nutritive value of the principal agricultural crops and forage plants of Central America and Panama, by the Institute of Nutrition of Central America and Panama, Guatemala City, Guatemala; $75,000.

WEST INDIES

JAMAICA

University College of the West Indies, Mona: equipment for the Regional Research Center of the Faculty of Agriculture; $3,700.

LATIN AMERICA

ARGENTINA

National Institute of Agricultural Technology, Buenos Aires: to invite Dr. F. Pimentel Gomes, professor of biometry, Luiz de Queiroz College of Agriculture, University of São Paulo, Piracicaba, Brazil, to teach at the institute; $2,000.

Ing. Ernesto Florencio Godoy, Pergamino Experiment Station: to visit experiment stations in Mexico, the United States, and Canada; $5,025.

University of Buenos Aires: equipment for the Departments of Agricultural and Veterinary Microbiology of the Faculty of Agronomy and Veterinary Science; $10,000.

BOLIVIA

University of San Simón, Cochabamba: development of agricultural education and research at the Faculty of Agronomy; $80,000.

BRAZIL

Rural University of the State of Minas Gerais, Viçosa: equipment for the School of Home Economics; $30,000.

São Paulo State Secretariat of Agriculture, São Paulo:

Equipment for research in plant biochemistry, fungicides, biochemistry, and pharmacodynamics at the Institute of Biology; $30,000;

Research on plant viruses at the Institute of Agronomy, Campinas; $16,500;

Temperature control equipment for a greenhouse for the Institute of Biology; $5,000;

Dr. Waldemar Ferreira de Almeida, Institute of Biology; to visit libraries and museums in New York and Washington, D.C.; $2,950;

Miss Victoria Rosetti, Institute of Biology; to visit citrus research centers in the United States; $2,750;

Dr. Agesilau Antonio Bitancourt, director, Division of Plant Biology, Institute of Biology; to visit the laboratories of Professor Jean Lecomte and Professor Roger Buvat at the University of Paris, France; $1,000.

University of Rio Grande do Sul, Pôrto Alegre:

Dr. Edgardo Jose Trein, professor of veterinary pathology; to visit veterinary colleges in Latin America, the United States, and Canada; $2,950;

Dr. Ruben Markus, assistant professor of genetics; to accompany the rector, Dr. Elyseu Paglioli, to the United States to observe the organization and operation of agricultural colleges and research institutions; $1,890.

Professor Hugo de Almeida Leme, acting director, Luiz de Queiroz College of Agriculture, University of São Paulo, Piracicaba; to observe the organization of courses on farm machinery at universities and factories in Europe, and to attend the International Technical Congress on Agricultural Machinery in Paris, France; $1,000.

CHILE

Ministry of Agriculture, Santiago:

Ing. Carlos Munoz Pizarro, coordinator of research in agriculture and animal husbandry; to review collections of Chilean plants in herbariums in Europe; $5,400;

Dr. Alfredo Mathieu, director, Southern Experiment Station, Temuco; to visit agricultural experiment centers in Colombia, Costa Rica, Mexico, and California; $2,470;

Dr. Mario Vallejo, director, Central Experiment Station; to visit agricultural experiment centers in Colombia, Costa Rica, Mexico, and California; $2,470;

Dr. Claudio Vergara, head, Department of Agricultural Research; to visit agricultural experiment centers in Colombia, Costa Rica, Mexico, and California; $2,470.

Dr. Wilfried Stubbe, director, Institute of Botany, University of the South, Valdivia: to visit laboratories and consult with scientists in the United States in connection with research on plastid inheritance in Evening Primrose; $600.

COLOMBIA

Ministry of Agriculture, Bogotá:

Miss Julia Guzmán-Naranjo, Division of Agricultural Research; to visit centers of research on potato diseases in the United States and Mexico; $3,200;

Equipment for the Fisheries Center Laboratory, Buenaventura, Valle del Cauca; $1,200.

National University of Colombia, Medellín: field equipment for the Faculty of Agronomy and the Forestry Institute; $10,000.

COSTA RICA

Inter-American Institute of Agricultural Sciences, San José:

Expenses of the Biological Sciences Review Team and the Review Panel examining present institute activities and developing recommendations for improvements and new projects; $10,000;

Miss Olga Lendvayova, chief librarian; to visit agricultural libraries in the United States and Mexico and to attend a workshop at the Columbia University Library School, New York; $2,000.

Inter-American Society of Agricultural Scientists, Turrialba: to help meet the expenses of the fifth meeting held in Buenos Aires, Argentina, during 1961; $25,000.

GUATEMALA

Ministry of Agriculture, Guatemala City: books and journals for the library of the National Agricultural Institute; $2,500.

HONDURAS

Pan American Agricultural School, Tegucigalpa: equipment, staff training, scholarships, and library development; $75,000.

MEXICO

Ing. Angel Vergara Castillo, manager, El Palmar Experiment Station, and in charge of the Hevea Rubber Program in the States of Veracruz and

Oaxaca, Ministry of Agriculture, Cosolapa: to visit the Federated Malay States and Indonesia to observe research methods and propagation systems for basic tropical crops and plantations of interest to tropical Mexico; $2,510.

National School of Agriculture, Chapingo: development of the program and facilities of the Graduate College; $90,000.

National University of Mexico, Mexico City: development of teaching and research in the School of Veterinary Medicine; $145,000.

Ing. Leonel Robles Gutiérrez, dean, School of Agriculture and Animal Husbandry, Technological Institute and School of Advanced Studies of Monterrey: to visit Departments of Animal Husbandry at colleges and universities in the United States; $1,260.

University of Coahuila, Antonio Narro College of Agriculture, Saltillo:

> Ing. Oscar Fuentes del Valle; to attend the International Symposium on Seed Potatoes held in Wageningen, Netherlands, during June, 1961; $2,050;
>
> Ing. Gabriel Murillo Peralta; to attend the International Symposium on Seed Potatoes held in Wageningen, Netherlands, during June, 1961; $2,050.

University of Sonora, School of Agriculture and Animal Husbandry, Hermosillo:

> Development of teaching and research; $100,000;
>
> Dr. Jose Dula Navarrete, subdirector; to participate in the training program given by the United States Department of Agriculture Agricultural Research Service at the United States Salinity Laboratory, Riverside, California; $1,000;
>
> Studies of the diagnosis and control of common animal diseases of the region, by Dr. Raul Hidalgo; under the supervision of Dr. William J. Pistor, Animal Pathology Laboratory, University of Arizona, Tucson; $800.

NICARAGUA

Ministry of Agriculture and Animal Industry, Managua: equipment for use in connection with the Cooperative Maize Improvement Program in Central America; $10,000.

PERU

Agrarian University, La Molina, Lima:

> Dr. Ferruccio Accame, dean, Faculty of Zootechnology; to visit departments of animal husbandry at colleges and research centers in the United States, Mexico, Costa Rica, Colombia, and Brazil; $3,950;
>
> School of Animal Husbandry; expenses of a national scientific symposium on animal husbandry held in Lima in May, 1961; $2,900.

Mrs. Amalia Cavero y Cornejo, chief librarian, Agricultural Experiment Station, La Molina, Ministry of Agriculture, Lima: to visit agricultural libraries in the United States for inservice training; $3,250.

Dr. Teodoro Ramos Saco, dean, School of Veterinary Medicine, University of San Marcos, Lima: to serve as consultant and advisor to the School of Veterinary Medicine, University of the South, Valdivia, Chile, and to the School of Veterinary Medicine and Animal Husbandry, University of San Carlos, Guatemala City, Guatemala; $2,695.

URUGUAY

Dr. Edwin Raul Castro, Faculty of Veterinary Science, University of the Republic, Montevideo: to study, in Scotland, specialized immunization techniques against parasitic diseases; $1,634.

EUROPE

ITALY

Catholic University of the Sacred Heart, Milan: research on maize genetics at the Institute of Plant Genetics, Piacenza; $13,000.

Food and Agriculture Organization of the United Nations, Rome: training awards to enable scientists from the Middle East to study wheat and small grain improvement methods at The Rockefeller Foundation's cooperative agricultural programs in Mexico and Colombia; $150,000.

NETHERLANDS

Dr. C. T. de Wit, senior research officer, Institute for Biological and Chemical Research on Field Crops, Agricultural University, Wageningen: to accept a one-year appointment as consultant, Soil and Water Conservation Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland; $1,780.

POLAND

Tadeusz Zeligowski, director, Central Agricultural Library, Warsaw: to confer with library officials in the United States and Europe; $2,945.

Central College of Rural Economics, Warsaw: scientific instruments for the laboratories concerned with agricultural and food industries; $10,000.

College of Agriculture, Lublin:

Equipment for the Veterinary Faculty; $5,000;

Dr. Stefan Ziemnicki, professor of soil science; to visit centers of research on soil conservation in the United States; $3,590;

Dr. Czeslaw Tarkowski, adjunct, chair of plant breeding; to visit centers of research on plant polyploidy in Sweden; $3,065.

College of Agriculture, Poznan:

Equipment for research in plant pathology; $4,500;

Purchase and installation of research equipment for the Institute of Biochemistry and the Department of Plant Physiology; $3,100.

Dr. Aleksander Rejman, assistant professor, College of Agriculture, |Warsaw: to visit centers of research on fruit breeding in the United Kingdom; $1,780.

Institute of Plant Protection, Poznan:

Equipment for the virus laboratory; $56,000;

Dr. Andrzej Wilski, head, Helminthology Laboratory; to visit centers of research in nematology and related fields in Europe; $2,445.

Dr. Waldemar Ostrowski, head, Storage and Transport of Fruit Department, Research Institute of Pomology, Skierniewice: to visit centers of research on fruit physiology in the United States; $2,615.

Dr. Henryk Janowski, head, Department of Swine Diseases, Veterinary Institute of Pulawy: to visit centers of research on swine pathology in the United States; $3,540.

PORTUGAL

National Agricultural Experiment Station, Sacavém: publications for the library of the Coffee Rust Research Center, Oeiras; $1,800.

SPAIN

School of Agriculture, Madrid: publications, primarily in the field of genetics, for the library; $10,000.

UNITED KINGDOM

Kenneth George Proudfoot, senior scientific officer, Ministry of Agriculture, Northern Ireland, Belfast: to study potato blight and the breeding of resistant potato varieties at The Rockefeller Foundation Mexican Agricultural Program while in North America; $1,050.

Dr. Conrad Ellenby, reader in plant nematology, King's College, University of Durham, Newcastle upon Tyne, England: to visit centers of research in nematology in the United States; $2,615.

AFRICA

CONGO

Dr. Arthur Ringoet, head, Division of Plant Physiology, National Institute for Agronomic Research in the Congo, Yangambi: to undertake studies in the field of plant science in the United States; $3,810.

GHANA

Kumasi College of Technology: teaching and research equipment for the School of Agriculture; £15,000 (about $42,750).

Ministry of Agriculture, Accra:

Frederick Maxwell Amfo Sackey, poultry development officer, Division of Agriculture, Pokoase; to visit centers of research in poultry science in the United States; $5,900;

A. S. A. Abban, ministerial secretary; to visit centers of agricultural research in the United States; $3,350;

Alfred Ernest Chinbuah, principal secretary; to visit large-scale mechanized farming projects and to consult with farm management specialists in the United States; $2,990.

KENYA

East Africa High Commission, Nairobi:

Research on sorghum at the East African Agriculture and Forestry Research Organization, Serere, Uganda; $60,000;

Equipment for the East African Marine Fisheries Research Organization, Zanzibar; $10,000.

Ministry of Agriculture, Animal Husbandry, and Water Resources, Nairobi:

Plant Breeding Station, Njoro; research on cereal rusts; $100,000;

Expenses of the educational program of the farm institutes of the Department of Agriculture; $5,000;

E. J. Guthrie, plant pathologist, Department of Agriculture; to visit centers of research in plant pathology in the United States, Canada, and Mexico; $4,700;

Giles E. Dixon, plant scientist, Plant Breeding Station, Njoro; to observe the wheat improvement activities of The Rockefeller Foundation Mexican Agricultural Program while in North America; $810.

LIBERIA

Cuttington College, Suacoco: support of the agricultural teaching and research program; $10,000.

NIGERIA

Dr. Fields Caveness, nematologist, International Development Services Section, Moor Plantation, Ibadan: to attend a conference on plant parasitic nematodes held in Kikuyu, Kenya; $606.

Ministry of Economic Development, Moor Plantation, Ibadan:

P. M. Chinwuba, agronomist, Federal Department of Agricultural Research; to visit centers of maize research in the United States and Mexico; $4,690;

Laurence A. Mound, specialist officer, Federal Department of Agricultural Research; to carry on entomological investigations with Miss Louise Russell, United States Department of Agriculture, Washington, D.C.; $2,420.

A. Muhammadu Maccido, councillor for natural resources, Sokoto Native Authority: to visit agricultural centers in the United States and Puerto Rico; $4,265.

University College, Ibadan: research in the Faculty of Agriculture on food crop production; $6,500.

RHODESIA AND NYASALAND

University College of Rhodesia and Nyasaland, Salisbury:

Development of research and teaching in the agricultural sciences; $75,000;

Dr. J. H. Topps, lecturer in animal nutrition; to visit centers of research in animal science in the United States; $1,450.

SUDAN

University of Khartoum:

Development of teaching and research in the Faculties of Agriculture, Science, and Veterinary Science; $70,000;

Dr. K. A. Agabawi, Faculty Farm, Faculty of Agriculture; to study patterns of crop production in the United States; $4,240;

Dr. Mohamed A. Nour, dean, Faculty of Agriculture; to study modern developments in plant virus research techniques in the United Kingdom and the United States; $3,945.

TANGANYIKA

Western Regional Research Centre, Ukiriguru: equipment for research in plant science; $10,000.

UGANDA

Makerere College, Faculty of Agriculture, Kampala: to construct and furnish a guest house for visiting scientists at the College Farm, Kabanyolo; $10,000.

MIDDLE EAST

ISRAEL

Y. Atsmon, wheat breeder, Research Department, Mivhor Farm, Sde Gat: to conduct wheat breeding research at The Rockefeller Foundation Colombian Agricultural Program; $3,235.

National Physical Laboratory of Israel, Jerusalem: research in solar energy, under the direction of Dr. H. Tabor; $80,000.

SOUTH ASIA

CEYLON

Dr. Henry E. Fernando, head, Division of Entomology, Department of Agriculture, Peradeniya: to visit centers of entomological research in the United Kingdom, the United States, and Japan; $5,675.

INDIA

Central Potato Research Institute, Ministry of Food and Agriculture, New Delhi: laboratory and field research equipment; $65,000.

Harish Chandra Saxena, lecturer in animal husbandry and dairying, Rajasthan College of Agriculture, Udaipur: to accept a research assistantship to study for the doctoral degree at Washington State University, Pullman; $1,200.

Dr. B. M. Johri, Department of Botany, University of Delhi: to visit laboratories in the United States; $4,300.

FAR EAST

AUSTRALIA

Dr. Albert T. Pugsley, director, Agricultural Research Institute, Wagga: to visit centers of research on wheat breeding in Latin America; $5,060;

Commonwealth Scientific and Industrial Research Organization:

> Dr. W. W. Emerson, senior research officer, Division of Soils, Adelaide; to accept a one-year appointment as soil physicist, Soil and Water Conservation Research Division, Agricultural Research Service, United States Department of Agriculture, St. Paul, Minnesota; $2,800.
>
> Dr. J. Griffiths Davies, chief, Division of Tropical Pastures, St. Lucia; to attend the Pan Pacific Science Congress in Honolulu, Hawaii, during August, 1961; $1,000.

Dr. Olli Vaartaja, Waite Agricultural Research Institute, University of Adelaide: to attend the International Bioclimatological Conference in London, England, and to visit forest research institutes in Rome and Madrid en route from Canada to Australia; $1,615.

JAPAN

Kiyosato Educational Experiment Project, Tokyo: expenses of the second national veterinary conference at Kiyosato; $1,500.

Dr. Kosuke Yamashita, professor of biology, Yoshida College, Kyoto University: to visit research centers in Europe and Asia and to attend a meeting of the United Nations Food and Agriculture Organization in Rome, Italy; $2,200.

Kyushu University, Fukuoka: equipment for the Department of Biochemistry, Faculty of Agriculture; $2,838.

Nagoya National University:

> Department of Agricultural Chemistry, Faculty of Agriculture; equipment for biochemical research; $56,000;
>
> Dr. Seiichi Nakajo, professor of animal breeding, Faculty of Agriculture; to visit poultry and animal science centers in the United States and Europe; $4,500.

National Institute of Animal Health, Tokyo: library materials; $5,000.

University of Tokyo: equipment and supplies for research in the agricultural sciences; $50,000.

NEW ZEALAND

C. M. Driver, leader, Potato Section, Crop Research Division, Department of Scientific and Industrial Research, Christchurch: to visit centers of potato research in the United States, Canada, Mexico, and Europe; $1,300.

PHILIPPINES

Bureau of Soils, Department of Agriculture and Natural Resources, Manila: laboratory equipment and supplies; $2,000.

International Rice Research Institute, Los Baños: operating expenses; $229,000.

Professor Nicolas L. Galvez, head, Department of Soils, College of Agriculture, University of the Philippines, Los Baños: to attend the Seventh International Soil Science Congress and to visit state universities in the United States; $3,410.

Publications 1960-1961

MEXICAN AGRICULTURAL PROGRAM

CORN AND SORGHUM

BARRIENTOS, FACUNDO and GILBERTO PALACIOS DE LA ROSA. Maíces mejorados para la Mesa Central. Circular El Horno No. 5, September, 1960.

BRAUER H., OSCAR and MARCOS RAMÍREZ GENEL. El totomoxtle como protector de la mazorca. Agricultura Técnica en México No. 10, Summer, 1960.

MÁRQUEZ S., FIDEL, PEDRO REYES C., and ELMER C. JOHNSON. El achaparramiento del maíz en Veracruz. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

MUÑOZ, JUAN MANUEL and ROBERT D. OSLER. Sorgos para grano. Boletín de Extensión Agrícola No. 345, December, 1960.

MUÑOZ, JUAN MANUEL. Epoca óptima de corte de los sorgos forrajeros para ensilaje. Agricultura Técnica en México No. 10, Summer, 1960.

PUENTE BERUMEN, ARMANDO, PEDRO REYES C., FIDEL MÁRQUEZ SÁNCHEZ, and E. C. JOHNSON. Ensayo de maíz tropical con tres variantes: combate de hierbas, distribución de semilla y abonado. Agricultura Técnica en México No. 10, Summer, 1960.

REYES C., PEDRO, FIDEL MÁRQUEZ S., JOAQUÍN ORTIZ C., and ELMER C. JOHNSON. H-507, nuevo maíz híbrido para zonas tropicales. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

WHEAT AND BARLEY

BORLAUG, NORMAN E., IGNACIO NARVÁEZ M., GREGORIO VÁZQUEZ G., REGGIE J. LAIRD, WILLIAM R. YOUNG, JOSÉ MORALES ARMENDÁRIZ, and ADOLFO FERNÁNDEZ. Recomendaciones para el cultivo de trigo en los valles altos de la Mesa Central y del Norte de México. Boletín de Extensión Agrícola No. 325, August, 1960.

BORLAUG, NORMAN E., IGNACIO NARVÁEZ M., GREGORIO VÁZQUEZ G., REGGIE J. LAIRD, WILLIAM R. YOUNG, JOSÉ MORALES ARMENDÁRIZ, and JUAN DEL TORO G. Recomendaciones para el cultivo de trigo en la región del Bajío. Boletín de Extensión Agrícola No. 326, February and August, 1961.

BORLAUG; NORMAN E., IGNACIO NARVÁEZ M., GREGORIO VÁZQUEZ G., JOSÉ MORALES ARMENDÁRIZ, HÉCTOR PORRAS H., and ADOLFO FERNÁNDEZ S. Recomendaciones para el cultivo de trigo en la Comarca Lagunera. Boletín de Extensión Agrícola No. 328, August, 1960.

CAMPOS T., ALFREDO, NORMAN E. BORLAUG, ALFREDO GARCÍA S., and GREGORIO VÁZQUEZ. Selección de variedades de garbanzo en tres regiones de México. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

GARCÍA S., ALFREDO, SAMUEL AGUILAR YÉPEZ, IGNACIO NARVÁEZ M., JUAN A. SIFUENTES, JOSÉ MORALES ARMENDÁRIZ, and ADOLFO FERNÁNDEZ. Recomendaciones para el cultivo de trigo en la Costa Noroeste del Pacífico. Boletín de Extensión Agrícola No. 327, September, 1960.

NARVÁEZ M., IGNACIO, GREGORIO VÁZQUEZ G., and ALFREDO GARCÍA SÁNCHEZ. La cebada produce bien en el Bajío. Recomendaciones, Ciclo 1960-1961. Boletín de Extensión Agrícola No. 331, September, 1960.

NARVÁEZ M., IGNACIO, GREGORIO VÁZQUEZ G., and ALFREDO GARCÍA SÁNCHEZ. La cebada produce bien en los valles altos; recomendaciones, Ciclo Verano, 1961. Boletín de Extensión Agrícola No. 331, October, 1960.

BEANS AND SOYBEANS

BARRIGA, CELIO and J. A. SIFUENTES. El cultivo de la soya en el Noroeste. Circular CIANO No. 13, March, 1961.

Cárdenas R., Francisco and José Luis Serrano P. Cómo cosechar más frijol en el trópico. Circular Cotaxtla No. 9, April, 1961.

Crispín M., Alfonso. Cruzamiento natural en el frijol. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Guevara C., José, Graciano Patiño, and Eduardo Casas. Selección de variedades de frijol resistentes al picudo del ejote. Agricultura Técnica en México No. 10, Summer, 1960.

POTATOES

Campos, Armando and Jesús Fernández. El cultivo de la papa en el Valle de México. Circular El Horno No. 4, September, 1960.

HORTICULTURE

Baca Castillo, Gustavo. Las hortalizas de buena calidad representan mayores ingresos: col y cebolla. Novedades Hortícolas Vol. VI, No. 1, January-March, 1961.

Brauer H., Oscar. La "cura" del camote al sol perjudica su conservación. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Contreras, Juventino. La malanga: un buen cultivo para el trópico. Novedades Hortícolas Vol. V, No. 4, October-December, 1960.

Guzmán Martínez, Enrique, Ernest H. Cásseres, and Alfonso Ortega Andapia. Principales plagas en las hortalizas y su combate (Revisión de Literatura). Novedades Hortícolas Vol. V, Nos. 2 and 3, April-June, 1960, July-September, 1960.

Guzmán Martínez, Enrique. Recomendaciones para el cultivo del chícharo en el Valle de Toluca. Novedades Hortícolas Vol. VI, No. 1, January-March, 1961.

Kohashi Shibata, Josué. Nafta y Petróleo: herbicidas selectivos en el cultivo de la zanahoria. Agricultura Técnica en México No. 10, Summer, 1960.

Laborde Cancino, José. La secadera de las plantitas en los almácigos. Novedades Hortícolas Vol. VI, No. 1, January-March, 1961.

Medina B., Jorge. Efecto de variedades y selección de semilla en el rendimiento de ajo. Agricultura Técnica en México No. 10, Summer, 1960.

Muñoz Flores, Ignacio. Sugestiones para la producción de semilla de cebolla. Novedades Hortícolas Vol. V, No. 4, October-December, 1960.

Muñoz Flores, Ignacio. Nuevas variedades de cebolla para el Noroeste. Novedades Hortícolas Vol. VI, No. 1, January-March, 1961.

Nieto H., Víctor. Nuevas variedades de melón para el Noroeste. Novedades Hortícolas Vol. V, No. 4, October-December, 1960.

Nieto H., Víctor. Observaciones sobre adaptación de variedades de melón en el Valle del Yaqui. Agricultura Técnica en México No. 10, Summer, 1960.

FORAGE GRASSES AND LEGUMES

Alvarez Gómez, Angel and professional staff of the Meteorological Service of Chihuahua. Boletín Meteorológico Estado de Chihuahua, 1959. Circular La Campana No. 6, November, 1960.

Buller, Roderic E. Evaluation of the forage resources of the tropical grasslands of Mexico. Proceedings of the Eighth International Grassland Congress, 1960, pp. 374-377.

Buller, Roderic E., Arturo Sánchez D., and Ricardo Garza T. Efecto del estado de madurez al tiempo de corte en la producción y población de la alfalfa en el Valle de México y el Bajío. Folleto Técnico No. 40, September, 1960.

Buller, Roderic E., Marcial Velasco, and Héctor Jaramillo. Composición química de zacates nativos importantes en distintos tipos de pastizales en Chihuahua. Agricultura Técnica en México No. 10, Summer, 1960.

Buller, Roderic E., Martín H. González, and Carlos López de la Garza. Ensayos de pastoreo con novillos en un pastizal alcalino. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Garza T., Ricardo and Roderic E. Buller. Comportamiento de leguminosas y zacates forrajeros en la región del Bajío. Folleto Técnico No. 41, October, 1960.

Garza T., Ricardo and Roderic E. Buller. El trébol rojo produce buen forraje en las zonas frías y humedad. Circular El Horno No. 6, January, 1961.

Garza T., Ricardo and Roderic E. Buller. Trébol ladino. Leguminosa suculenta para el ganado. Circular El Horno No. 7, January, 1961.

Martínez Martínez, Fiacro. Distribución y habitat de la alfombrilla en México. Agricultura Técnica en México No. 10, Summer, 1960.

Martínez Martínez, Fiacro. Composición florística de los pastizales del Rancho Experimental La Campana. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Professional staff of La Campana. Centro de investigación sobre pastizales del Noroeste—3 años de labores. Circular La Campana No. 5, August, 1960.

Tapia Jasso, Carlos and professional staff of the Forage Section at Cotaxtla. El programa de investigación forrajera en el trópico. Circular Cotaxtla No. 8, October, 1960.

Tapia Jasso, Carlos and Angel Ramos S. Zonas de vegetación en la parte central del Estado de Veracruz. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

SOILS

Chávez R., Sabino and Reggie J. Laird. El uso consuntivo diario del agua por el trigo en el Bajío. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Laird, Reggie J. La fertilización del maíz. Memoria de la VI Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, Nicaragua, February, 1960.

Núñez E., Roberto, Reggie J. Laird, Rafael Hernández S., and Zeferino Arvizu R. Variaciones en la humedad del suelo durante el ciclo del trigo en el Bajío y su influencia en varias características del cultivo. Folleto Técnico No. 38, May, 1960.

Ramírez P., Félix and Reggie J. Laird. Densidad optima de plantas de maíz para los Valles de México y Toluca. Folleto Técnico No. 42, December, 1960.

Ramírez P., Félix and Reggie J. Laird. ¿Cómo afectan la producción de alfalfa las aplicaciones de fósforo y estiércol? Agricultura Técnica en México No. 10, Summer, 1960.

Ruiz M., Justo and Reggie J. Laird. Tres leguminosas tropicales para abono verde. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

ENTOMOLOGY

Candia Z., Daniel and William R. Young. Repelentes contra pájaros durante la germinación del maíz en el trópico. Agricultura Técnica en México No. 10, Summer, 1960.

Carrillo S., José Luis and William W. Gibson. Repaso de las especies mexicanas del género *Macrodactylus* (Coleoptera, Scarabaeidae), con observaciones biológicas de algunas especies. Folleto Técnico No. 39, August, 1960.

Gibson, William W. Cómo manejar y usar la colección de insectos. Folleto Misceláneo No. 10, July, 1960.

Guevara C., José. Variedades de frijol resistentes a las plagas. Boletín Técnico de la Sociedad Agronómica II: 17-26.

Quintana, Rodolfo. ¡Cómo proteger su cosecha contra las plagas! Circular El Horno No. 3, September, 1960.

Quintana, Rodolfo, Donald A. Wilbur, and William R. Young. Insectos del grano almacenado que infestan al maíz en el campo. Agricultura Técnica en México No. 10, Summer, 1960.

Sifuentes, J. Antonio and W. R. Young. El gusano peludo *Estigmene acrea* (Drury): biología, hospederas, enemigos naturales y efectividad de algunos insecticidas para su combate en el Valle del Yaqui. Folleto Técnico No. 43, February, 1961.

Sifuentes, J. Antonio. Plagas de insectos en el Valle del Yaqui en 1959. Circular CIANO No. 10, May, 1960.

Sifuentes, J. Antonio and William R. Young. Plagas de los cultivos en el Valle del Yaqui en 1960. Circular CIANO No. 11, January, 1961.

Sifuentes, J. Antonio and William R. Young. Recomendaciones para el combate químico de las plagas del algodonero en el Valle del Yaqui en 1961. Circular CIANO No. 12, February, 1961.

Sifuentes, J. Antonio and William R. Young. El pulgón manchado reduce la población de alfalfa. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Sifuentes, J. Antonio, Joel Rodríguez V., and William R. Young. Efecto del thimet sobre el trips del algodonero en el Valle del Yaqui. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Wilbur, Donald A., Rodolfo Quintana, and Douglas Barnes. Temperaturas observadas en trigo almacenado en Toluca. Agricultura Técnica en México No. 10, Summer, 1960.

Young, William R., Peter R. Jennings, and Neftalí Calixto Cruz. ¿Existe en México la hoja blanca del arroz? Agricultura Técnica en México No. 10, Summer, 1960.

PLANT PATHOLOGY

Christensen, Clyde M., Luis César López, and Rodolfo Quintana R. ¿Qué tan exacto es su aparato medidor de humedad? Agricultura Técnica en México No. 10, Summer, 1960.

POULTRY

Bixler, Edsel and John A. Pino. El guajolote. Nueva perspectiva para la industria avícola. Agricultura Técnica en México No. 10, Summer, 1960.

Perry, Jesse P., Jr. and John A. Pino. Gallineros para el trópico. Agricultura Técnica en México No. 10, Summer, 1960.

Pino, John A. Las enzimas mejoran el valor alimenticio de la cebada. Agricultura Técnica en México No. 11, Winter-Summer, 1960-1961.

Pino, John A. Proyectos para gallineros. Industria Avícola No. 15, January, 1961.

Pino, John A. La construcción de gallineros. Industria Avícola No. 16, April, 1961.

Professional staff of the Cooperative Agricultural Program of the Ministry of Agriculture and The Rockefeller Foundation. I Symposium de la Enfermedad de Newcastle. Folleto Misceláneo No. 11, December, 1960.

AGRICULTURAL INFORMATION

Myren, Delbert T. Barreras que impiden la adopción de maíces mejorados y prácticas mejoradas en el cultivo del maíz. Memoria de la VI Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, Nicaragua, February, 1960.

Professional staff of the department of technical information. El Campo Cotaxtla y la agricultura tropical. Edición conmemorativa de la Inauguración del Centro de Investigación Agrícola e Industria Animal para Zonas Tropicales, por el C. Lic. Adolfo López Mateos, Presidente de la República, October, 1960.

MISCELLANEOUS

Larson, R. E. La modificación de la calidad de las hortalizas debida a la influencia de la variedad y del medio ambiente en el cual se cultivan. Revista de la Sociedad Mexicana de Historia Natural, Vol. XXI, No. 2, December, 1960.

Stakman, E. C. Importancia del estudio de la historia natural y su enseñanza. Revista de la Sociedad Mexicana de Historia Natural, Vol. XXI, No. 2, December, 1960.

COLOMBIAN AGRICULTURAL PROGRAM

CORN

Paper Presented

Timothy, David H. Genetic diversity, heterosis, and the use of exotic stocks in maize in Colombia. Symposium on Quantitative Genetics and Plant Breeding, Raleigh, North Carolina, March, 1961.

WHEAT, BARLEY, AND OATS

Gibler, John W., Peter R. Jennings, and Charles F. Krull. Natural occurrence of hoja blanca on wheat and oats. Plant Disease Reporter 45: 34, 1960.

Krull, Charles F. Genetic variability in oats following hybridization and radiation. Agronomy Abstracts, p. 50, 1960.

Krull, Charles F. and John W. Gibler. Oat breeding in Colombia. 1960 Oat Newsletter, p. 35, 1961.

Krull, Charles F. and Kenneth J. Frey. Genetic variability in oats following hybridization and radiation. Crop Science 1: 141-146, 1961.

RICE

Beachell, H. M. and Peter R. Jennings. Mode of inheritance of hoja blanca resistance in rice. Proceedings of the Ninth Meeting of the Rice Technical Working Group, Lafayette, Louisiana, 1960. Texas Agricultural Experiment Station Miscellaneous Publication 488: 11-12, 1961.

Jennings, Peter R. and H. M. Beachell. Hoja blanca disease of rice found in Mexico. Plant Disease Reporter 44: 751, 1960.

Jennings, Peter R. La enfermedad espiga erecta del arroz. Arroz 10: 17-18, 1961.

Jennings, Peter R. Historia del cultivo del arroz en Colombia. Agricultura Tropical XVII: 79-89, 1961.

POTATOES

Estrada R., Nelson. Herencia del albinismo en dos especies de papa. Agricultura Tropical XVI: 348-352, 1960.

Estrada R., Nelson. Las variedades mejoradas, la selección de semillas y el fomento agrícola. Agricultura Tropical XVI: 629, 1960.

Estrada R., Nelson. Nuevas variedades de papa para Colombia y producción de semilla inspeccionada. Agricultura Tropical XVI: 783-787, 1960.

Ranjel, Carlos E., Lee E. Heidrick, and Nelson Estrada R. Diacol-Cumbal, una nueva variedad de papa. Agricultura Tropical XVI: 788-795, 1960.

PASTURE AND FORAGE CROPS

Chaverra G., Hernán. La producción de alfalfa en Colombia. X. Comportamiento de la alfalfa sembrada simultáneamente con gramíneas. Agricultura Tropical XVI: 279-290, 1960.

Crowder, Loy V., Hernán Chaverra, and Alfonso Bastidas R. La producción de alfalfa en Colombia. XI. Siembra de gramíneas en alfalfares. Agricultura Tropical XVI: 353-371, 1960.

Crowder, Loy V., Silvio Echeverri, and Jaime Vanegas. Altura y frecuencia de corte de los pastos ryegrass, azul orchoro y kikuyo en mezcla con trébol blanco. Agricultura Tropical XVI: 372-382, 1960.

Crowder, Loy V. La producción de gramíneas y leguminosas en Colombia. I. Estudio de variedades de trébol blanco. Agricultura Tropical XVI: 383-392, 1960.

Crowder, Loy V., Angelo Michelín, and Alfonso Bastidás. Frecuencia de corte en gramíneas de clima cálido. Agricultura Tropical XVII: 201-209, 1961.

Crowder, Loy V. Gramíneas y leguminosas forrajeras en Colombia. Boletín Técnico No. 8, 1960.

Crowder, Loy V. Establecimiento y mantenimiento de pastos en Colombia. Boletín de Divulgación No. 9, 1960.

Echeverri E., Silvio. La producción de alfalfa en Colombia. IX. Efecto de la aplicación de fertilizantes, cal y elementos menores en la producción de la alfalfa sembrada en un suelo de la serie "Sabana de Bogotá." Agricultura Tropical XVI: 215-231, 1960.

Echeverri E., Silvio, Loy V. Crowder, and Hernán Chaverra G. Establecimiento y fertilización de pastos en siembra simultánea con avena roja. Agricultura Tropical XVI: 561-571, 1960.

Lotero C., Jaime and Loy V. Crowder. La producción de gramíneas y leguminosas en Colombia. II. Estudio de variedades de trébol rojo. Agricultura Tropical XVI: 392-400, 1960.

Lotero C., Jaime, Rodrigo Ramírez O., and Loy V. Crowder. Estudio preliminar de la asociación del pasto pará con leguminosas. Agricultura Tropical XVI: 450-455, 1960.

Lotero C., Jaime. Elementos menores en pasto. Agricultura Tropical XVII: 98-105, 1961.

Marín M., Gildardo. La producción de alfalfa en Colombia. VIII. Encalamiento de los suelos de la Sabana de Bogotá, para cultivar alfalfa. Agricultura Tropical XVI: 149-160, 1960.

Marín M., Gildardo, Loy V. Crowder, Guy B. Baird, and Rodrigo Ramírez. Reservas de elementos nutritivos con dos mezclas de gramíneas y leguminosas. Agricultura Tropical XVI: 359-372, 1960.

Riveros R., Guillermo. Comportamiento del pasto pangola asociado con leguminosas. Agricultura Tropical XVI: 769-782, 1960.

Varela M., James and Loy V. Crowder. Métodos de establecimiento de pasto pangola. Agricultura Tropical XVI: 400-409, 1960.

Vidal, Carlos G. Asociación de pasto pará con leguminosas. Agricultura Tropical XVII: 166-167, 1961.

SOIL SCIENCE

Baird, Guy B., Víctor M. Vega J., and Agathon Wieczorek. Ensayos preliminares sobre respuesta del maíz de clima frío a la aplicación de fertilizantes. Agricultura Tropical XVI: 233-240, 1960.

Marín M., Gildardo, Hernán Chaverra G., Loy V. Crowder, and Guy B. Baird. Fertilización de la alfalfa en suelos de clima frío de Colombia. Boletín Técnico No. 7, 1960.

Rodríguez J., Manuel, Guy B. Baird, and Jairo Correa V. Fertilización de la papa en Antioquia. Boletín Técnico No. 5, 1960.

Vega J., Víctor M., Genaro Díaz R., and Guy B. Baird. Fertilización de la papa en la Sabana de Bogotá y alrededores. Boletín Técnico No. 6, 1960.

PLANT PATHOLOGY

Galvez, Guillermo E. and Canuto Cardona A. Razas de *Rhizoctonia solani* Kühn en fríjol. Agricultura Tropical XVI: 456-457, 1960.

Galvez, Guillermo E., H. David Thurston, and Peter R. Jennings. Transmission of the hoja blanca disease of rice. Proceedings of the Ninth Meeting of the Rice Technical Working Group, Lafayette, Louisiana, 1960. Texas Agricultural Experiment Station Miscellaneous Publication 488: 20, 1961.

Guzmán N., Julia, H. David Thurston, and Lee E. Heidrick. Naturaleza de la resistencia parcial de tres clones de papa al *Phytophthora infestans*. Agricultura Tropical XVI: 89-99, 1960.

Guzmán N., Julia, H. David Thurston, and Lee E. Heidrick. Nature of partial resistance of three species of potatoes to *Phytophthora infestans*. Phytopathology 50: 637, 1960. (Abstract.)

ENTOMOLOGY

Bravo, Gilberto, Alfredo Saldarriaga, and Carlos Carmona. Ensayos de insecticidas en polvo para la protección de granos almacenados. Agricultura Tropical XVI: 300-312, 1960.

Sanabria de Arévalo, Isabel and Robert F. Ruppel. La especie *Sogata orizicola* Muir, y otras allegadas, y la relación que tienen con el virus causante de la enfermedad "hoja blanca" del arroz. Agricultura Tropical XVI: 291-299, 1960.

DAIRY SCIENCE

Waugh, Robert K., Samuel Ramírez, and Bernardino Rodríguez. Rumen activity and other observations in young dairy calves. J. Dairy Sci. 43: 887, 1960. (Abstract.)

POULTRY

Sunde, Milton L. and Gonzalo Madiedo. Influencia del maíz, del millo y de un pigmento carotenal en el color de la yema del huevo. Agricultura Tropical XVI: 725-730, 1960.

Sunde, Milton L., Gonzalo Madiedo, and Omar Hincapié. Análisis químicos de algunos alimentos colombianos. Agricultura Tropical XVII: 157-161, 1961.

ANIMAL PATHOLOGY

Papers Presented

Casorso, D. Roy and Guillermo Mateus V. Control of *Dermatobia hominis* (Nuche) in cattle. The Conference of Research Workers in Animal Diseases, Chicago, Illinois, November, 1960.

Hincapié, Omar, D. Roy Casorso, and G. Rave. Aislamiento e identificación de Brucella sp. en la leche de bovinos. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Hincapié, Omar, James M. Fransen, and D. Roy Casorso. Colesterol y yodo en bovinos. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Mateus V., Guillermo, Carlos Carmona, Miguel Revelo, and D. Roy Casorso. Estudios preliminares sobre el ciclo de vida de la *Dermatobia hominis*. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Mateus V., Guillermo and D. Roy Casorso. El control del nuche. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Mateus V., Guillermo and D. Roy Casorso. Diagnosis de Listeriallosis en el ganado de San José del Nus. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Mateus V., Guillermo, Alfredo Serrano, and D. Roy Casorso. Control de bronquitis verminosa con Dictycide. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Morales A., Néstor, D. Roy Casorso, and Jorge Gallo C. Control de endoparásitos de las ovejas en la Sabana de Bogotá. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Rave, Gustavo and D. Roy Casorso. Informe progresivo de la incidencia de Brucellosis en Holsteins de la Sabana de Bogotá. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

Sánchez, O., D. Roy Casorso, and Jorge Gallo. Identificación y clasificación de endoparásitos en la oveja. I Reunión de Médicos Veterinarios del D.I.A., Bogotá, Colombia, August, 1960.

D.I.A.

Cardona A., Canuto. Líneas de fríjol resistentes a la roya, seleccionadas en el Centro Nacional de Investigaciones Agrícolas "Tulio Ospina" (Medellín). Agricultura Tropical XVII: 90-97, 1961.

Cardona A., Canuto. Enfermedades del fríjol en Colombia. Agricultura Tropical XVII: 225-228, 1961.

Cardona A., Canuto, Rodrigo Duarte, and S. Mancini. El uso de la radiación artificial en la agricultura y su aplicación al fríjol en Colombia. Agricultura Tropical XVI: 514-523, 1960.

Gartner N., Alvaro and Canuto Cardona A. Tamaño de parcela y número de replicaciones para experimentación en fríjol. Agricultura Tropical XVI: 572-574, 1960.

Ramírez C., Amalia. Guía de Publicaciones Técnicas de la División de Investigaciones Agropecuarias, D.I.A.

Rodríguez Z., Enrique. Hechura y manejo de semilleros. Agricultura Tropical XVI: 575-580, 1960.

Indian Agricultural Program

MAIZE

Sprague, E. W., N. L. Dhawan, and L. R. House. Increased food production with hybrid maize. Current Science 29: 295-297, 1960.

Progress Report of the Coordinated Maize Breeding Program, 1960.

SORGHUM

Rachie, K. O. and L. R. House. Collections of indigenous sorghums in India. Sorghum Newsletter 4: 51, 1961.

Progress Report of the Cooperative Sorghum Yield Trials, 1959-1960.

MISCELLANEOUS

Parker, Dorothy. Organization of an agricultural college library. Indian Journal of Agricultural and Veterinary Education 3: 60-61, August, 1960. (Summary.)

Parker, Dorothy. Maintenance and binding in a library. Indian Journal of Agricultural and Veterinary Education 3: 60-61, August, 1960. (Summary.)

Traywick, J. D. Role of agricultural engineering in India's economic development. Yojano 5: 35-38, January, 1961.

Ministry of Food and Agriculture, Government of India. Improved agricultural seeds—with emphasis on hybrid maize. 1960.

Paper Presented

Traywick, J. D. India's needs in agricultural processing and crop preservation. Agricultural Engineering Symposium, Kharagpur Institute of Technology, October, 1960.

Inter-American Maize Project

Wellhausen, E. J. Los manantiales que alimentan el Río de la Abundancia en la producción del maíz. Memoria de la VI Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, Nicaragua, February, 1960.

Wellhausen, E. J. El mejoramiento del maíz en México—avances actuales y proyección hacia el futuro. Revista de la Sociedad Mexicana de Historia Natural, Vol. XXI, No. 2, December, 1960.

Salazar B., Angel. Informe de labores del P.C.C.-M.M. por 1959. Memoria de la VI Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, Nicaragua, February, 1960.

Covarrubias, Ramón. Cruzas intervarietales, una gran posibilidad para los programas de mejoramiento del maíz en Latino América. Memoria de la VI Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, Nicaragua, February, 1960.

Memoria de la VI Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, February, 1960.

Paper Presented

Wellhausen, E. J. Genetic diversity, heterosis, and the use of exotic stocks in Mexico and Central America. Symposium on Quantitative Genetics and Plant Breeding, Raleigh, North Carolina, March, 1961.

Translation

Sprague, George F. Mejoramiento del maíz. (Translated by Angel Salazar B. and Alfredo Carballo). 1960. (Chapter V, "Corn Breeding," in: Sprague, George F., ed., Corn and Corn Improvement, Academic Press, 1955.)

International Rice Research Institute

Chandler, Robert F. and Sterling Wortman. The International Rice Research Institute. The Rice Journal 64: 4-7, 1961.

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Norman E. Borlaug, PH.D., *Director, Inter-American Wheat Improvement Project*
John S. Niederhauser, PH.D., *Director, Inter-American Potato Improvement Project*
Edwin J. Wellhausen, PH.D., *Director, Inter-American Maize Improvement Project*
William H. Hatheway, PH.D., *Associate Statistician*

INTERNATIONAL RICE RESEARCH INSTITUTE

Robert F. Chandler, Jr., PH.D., *Director*
Sterling Wortman, PH.D., *Associate Director*
Robert Letort, *Treasurer*
Peter R. Jennings, PH.D., *Pathologist*
Loyd Johnson, M.S., *Agricultural Engineer*
James C. Moomaw, PH.D., *Agronomist*

THE ROCKEFELLER FOUNDATION

Program in the

Agricultural Sciences

Director's Introduction

The year 1962 in the United States is being celebrated as the centennial for several significant actions that contributed substantially to the attainment of the abundant and efficient agriculture of this country. In 1862 President Lincoln signed into law the acts establishing the United States Department of Agriculture and the Land Grant Colleges. The centennial year is being observed by numerous and varied functions which have elicited differing responses from those who have participated in and observed these events. The accomplishments of the past 100 years are regarded as most satisfying by some agriculturists but others are fully cognizant that adjustments in domestic agricultural research, education, and extension programs are not being made with sufficient alacrity to meet the rapid changes in the nation's agricultural economy.

To those scientists and educators in the United States who are devoting their major efforts to aiding advancing nations meet their needs for food, fiber, and other products of agriculture, this centennial year emphasizes the importance of well-founded, well-staffed, and well-operated institutions in guiding the advancement of indigenous agricultural enterprises. It is increasingly apparent from experience in the technical cooperation programs that agricultural science and technology cannot be transferred directly and that some minimum research, designed to adapt selected innovations, is necessary. Also, the generation of new knowledge and materials to increase agricultural production, the assimilation and use of such new science and technology, and the training of scientists-educators to perpetuate these advances cannot be achieved through a conglomeration of uncoordinated technical assistance projects. The goal of each advancing nation preferably should be, therefore, the establishment of indigenous institutions that will meet national needs with the same efficiency as the USDA–Land Grant Colleges have combined to serve the citizens of the United States.

The year 1962 marks also the centennial of the passage of the Homestead Act, an important step in the evolution of more effective land use and development in the United States. Attention to improved patterns of land use in the Western Hemisphere has been accentuated through the terms of the Alliance for Progress. It is reasonable to assume that well-designed programs of agricultural research, education, and rural development would be helpful in providing an effective base for accelerated efforts to achieve more substantial contributions from agricultural lands in the respective national economies.

The Rockefeller Foundation program in the Agricultural Sciences is directing its efforts increasingly to the establishment of such agricultural institutions in those countries in which cooperative efforts have been in progress for some years.

Continuing attention is being given to the further development of the National Institute of Agricultural Research which was established in Mexico in January, 1961, under the decree of President Adolfo López Mateos which consolidated the former Office of Special Studies and other research institutions in the Ministry of Agriculture. The Foundation staff members in Mexico are continuing to furnish guidance to selected projects and to the general direction of the Institute program. Officers of the Foundation and representatives of other organizations have consulted with Minister of Agriculture Julián Rodríguez Adame to determine the additional steps that might be taken to accelerate the development of research, teaching, and extension or rural development programs in Mexico, designed not only to meet the requirements of Mexican agriculture but also to serve more broadly the needs of neighboring Latin American countries.

The contributions to agricultural advancement in Colombia made through the cooperative efforts of The Rockefeller Foundation and the Division of Agricultural Research have been widely recognized and served as the base for the Agricultural Institute of Colombia which was established by decree by President Alberto Lleras Camargo on June 15, 1962. This new institute is to be structured upon the Division of Agricultural Research of the Ministry of Agriculture and will provide for closer coordination of agricultural research, education, and extension within the country. Consideration is being given in Chile to the development of a similar agricultural institute that would furnish research and related services to guide agricultural development.

The experience with the Post Graduate School of the Indian Agricultural Research Institute, which was established with Foundation cooperation in October, 1958, has stimulated the Government of India to constitute a special committee to review the needs for improvement in agricultural education, research, and extension throughout the country. This special committee, which was chaired by a Foundation representative at the invitation of the Government of India, has assisted state governments in modifying current activities in their institutions and has also helped with the planning of legislation to authorize new or improved agricultural universities. Such legislation has been enacted in the United Provinces, the Punjab, Orissa, and Rajasthan, with legislation pending in several other states at the present time.

The inauguration of the International Rice Research Institute on February 7, 1962, marks a significant step in the provision of planned approaches to agricultural problems of international concern. The partnership of The Ford Foundation, The Rockefeller Foundation, and the University of the Philippines also reflects the increasing recognition of the value of a blending of efforts and resources to accelerate progress toward goals of mutual interest.

The operating programs in the Agricultural Sciences continue to furnish the core of the Foundation's activities in this field. The concentration of effort on well-defined problems permits the demonstration of the effectiveness of the application of science and technology to improvement of production and real income in agriculture. This report summarizes the varied activities in the operating programs in Mexico, Colombia, Chile, and India, as well as in the Inter-American Food Crop Improvement Program, and presents a record of measurable advances in the cooperative efforts to improve the production of food crops and livestock products.

The emphasis on training and education continues undiminished, in recognition of the importance of the trained manpower resource in the advancement of levels of living in newly emerging nations. Advances in U.S. agriculture trace directly to efforts of the many graduates of the colleges of agriculture who have moved into varying activities that contribute to increased efficiency in the agricultural industry. The present infusion of such trained personnel is at the rate of about 7,000 college graduates annually. If it is assumed that the agricultural college graduates of the past 40 years are still actively contributing either directly or indirectly to the agricultural economy, and if it is assumed further that the annual output from the colleges of agriculture during this period averaged about 5,000, the United States would, therefore, be benefiting from the efforts of approximately 200,000 such trained people. Regardless of the exact magnitude of the above figures there is little doubt about the impact of trained men and women in the agricultural sciences on advancements in the agricultural industry and economy of the United States. It is reasonable to assume that a similar substantial number of trained and devoted personnel will be required in each of the advancing countries to achieve similar progress in agricultural production and in raising levels of living. Such trained personnel will be required in the several categories ranging from graduates of secondary schools, vocational schools, and undergraduate colleges through graduate training to the M.Sc. and Ph.D. levels.

The major portion of the training and education in agriculture and the related sciences must be supplied through indigenous institutions. The Foundation is directing increased attention to the strengthening of such local educational programs. The Post Graduate School of the Indian Agricultural Research Institute is now furnishing advanced training to the M.Sc. and Ph.D. levels for about 400 students each year, of whom 45% are working for the Ph.D. degree and the balance for the M.Sc. degree. Since its inauguration in 1958, 25 students have completed requirements for the Ph.D. degree and 168 have finished their M.Sc. degree programs. The establishment of the Post Graduate School at the IARI has made it possible for the Foundation to direct its fellowship program increasingly to the select candidates from India who might benefit particularly from the opportunity to continue their Ph.D. or postdoctoral studies in foreign institutions. A similar effort to build a postgraduate training center is being continued in the cooperative program in Mexico and will be initiated in the new Agricultural Institute of Colombia. Appropriations and grants to institutions in Chile and other countries also will broaden the scope of such national or regional centers for agricultural education.

The direct support of scholars and fellows continues at a substantial level, with 236 students under Foundation support as of June 30, 1962. Although the larger number of scholars and fellows are selected from the countries in which the Foundation has operating programs, there is a rather widespread distribution of support, with students from 28 countries receiving training at 40 different schools in the United States and elsewhere.

The grants program has been modified somewhat to support more highly selected projects or activities that fall into categories of program interests of the Foundation in the Agricultural Sciences. The increasing availability of funds from U.S. government agencies and from other sources to support fundamental research in agriculture and its component or allied disciplines has encouraged somewhat greater selectivity by Foundation officers among the projects proposed by U.S. institutions. This does not reflect a change in appreciation for certain lines of research but rather a recognition that resources should be used in a complementary fashion in order to advance activities of interest in the domestic and foreign scene. The sense of urgency that is increasingly apparent both on the part of agencies engaged in furnishing technical assistance and on the part of the advancing countries also lends encouragement to the increased selectivity of projects for Foundation support to insure the efficient and effective use of available resources in helping to achieve the aspirations of mankind for improved levels of living throughout the world.

Financial Summary

Program in the Agricultural Sciences

1941 through 1961

OPERATING PROGRAMS

Mexican Agricultural Program	$7,949,668	
Colombian Agricultural Program	4,325,242	
Chilean Agricultural Program	2,165,550	
Indian Agricultural Program	2,883,102	
International Rice Research Institute	1,046,976	
Inter-American Food Crop Improvement Program*	633,079	
General	229,741	$19,233,358

FELLOWSHIPS AND SCHOLARSHIPS

Fellowships	$6,596,305	
Scholarships	1,491,307	8,087,612

GRANTS PROGRAM

United States	$7,026,859	
South America	5,121,338	
Far East	4,720,185	
Mexico	2,916,559	
Africa	1,739,548	
Europe	978,096	
Central America	910,648	
Near East	428,520	
Canada	10,622	
General	981,280	24,833,655
Total, 1941 through 1961		$52,154,625

* Includes former Central American Corn Improvement Program.

Mexican Agricultural Program

Personnel

MINISTRY OF AGRICULTURE

His Excellency, **Don Julián Rodríguez Adame,** ING. AGR., Minister of Agriculture
Jesús Patiño Navarrete, ING. AGR., Subsecretary of Agriculture
Daniel Mercado García, D.V.M., Subsecretary of Livestock (to May, 1962)
Oscar Valdés Ornelas, D.V.M., Subsecretary of Livestock
Esteban Uranga Prado, ING. AGR., Executive Officer

NATIONAL INSTITUTE OF AGRICULTURAL RESEARCH

(INSTITUTO NACIONAL DE INVESTIGACIONES AGRICOLAS—"INIA")

Rodolfo P. Peregrina Robles, PH.D., Director General
Ralph W. Richardson, Jr., PH.D., Codirector General
Douglas Barnes, PH.D., Assistant to Codirector General (to April, 1962)
John A. Pino, PH.D., Assistant to Codirector General
Nicolás Sánchez Durón, PH.D., Subdirector General
José Guevara Calderón, PH.D., Technical Subdirector
Damián Correu T., ING. AGR., Assistant to Technical Subdirector
José Luis Spota B., ING. AGR., Administrative Subdirector
David Mayés O., ING. AGR., Assistant to Administrative Subdirector
Luis G. Rivera G., ING. AGR., Assistant to Administrative Subdirector

THE ROCKEFELLER FOUNDATION

MEXICAN AGRICULTURAL PROGRAM

Ralph W. Richardson, Jr., PH.D., Local Director
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Roderic E. Buller, PH.D., Agronomist (to December, 1961)
Donald K. Freebairn, PH.D., Associate Agricultural Economist
Daniel D. Hagen, D.V.M., Animal Pathologist
Elmer C. Johnson, PH.D., Geneticist
Reggie J. Laird, PH.D., Soil Scientist
Neil B. MacLellan, Staff Photographer
Delbert T. Myren, PH.D., Information Specialist
Ned S. Raun, PH.D., Associate Animal Scientist
William R. Young, PH.D., Associate Entomologist (to January, 1962)

DIRECTORS OF INVESTIGATION AND OPERATION MANAGERS

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Lorenzo Vásquez Rojas, Manager, Santa Elena Experiment Station, Toluca, México

Miguel Bárcenas Gómez, ING. AGR., Manager, Iguala Experiment Station, Guerrero

Andrés Paredes Tijerina, ING. AGR., Manager, Zacatepec Experiment Station, Morelos

Javier Gil Flores, M.S., Director, El Roque Experiment Station, Celaya, Guanajuato

Rogelio Villarreal Guzmán, ING. AGR., Manager, La Cal Grande Experiment Station, La Piedad, Michoacán

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Angel Vergara Castillo, ING. AGR., Manager, El Palmar Experiment Station, Veracruz

Manuel Puente Cerda, ING. AGR., Manager, San José Puyacatengo Experiment Station, Tabasco

Jorge Martínez Lima, ING. AGR., Manager, El Cayal Experiment Station, Campeche, Campeche

Sabino Vázquez R., ING. AGR., Manager, Llera Experiment Station, Tamaulipas

VARIETAL IMPROVEMENT IN CORN AND SORGHUMS

Elmer C. Johnson, PH.D., Geneticist, The Rockefeller Foundation; Technical Advisor, INIA

Gilberto Palacios de la Rosa, ING., Head of Department, INIA

Hermilo Angeles Arrieta, M.S., Assistant Head of Department, INIA

Facundo Barrientos Pérez, M.S., in charge, Corn and Sorghum Program, El Horno, Chapingo

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Ciro Dehesa, ING. AGR., Investigator, El Horno, Chapingo

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Abel Muñoz, ING. AGR., Investigator, El Horno, Chapingo

Miguel Pedrizco, ING. AGR., Investigator, El Horno, Chapingo

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Jesús Neve Vargas, M.S., in charge, Corn Program, CIANO, Cd. Obregón

Oscar Cota Agramont, ING. AGR., Investigator, CIANO, Cd. Obregón

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Javier Medina, ING. AGR., Investigator, Río Bravo

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Ulises Ortiz P., ING. AGR., Investigator, Antúnez

Saturnino Martínez L., ING. AGR., Investigator, Iguala

Juan Manuel Muñoz, M.S. (on leave)

Joaquín Ortiz Cereceres, ING. AGR. (on leave)

VARIETAL IMPROVEMENT IN SMALL GRAIN CROPS

Ignacio Narváez M., PH.D., Head of Department, INIA

Rodolfo Moreno G., ING. AGR., Assistant Head of Department, INIA

Jacobo Ortega C., PH.D., Chief of Wheat Improvement Section, INIA

Antonio Marino A., M.S., Investigator, Wheat, El Horno, Chapingo

Genaro Cruz R., ING. AGR., Investigator, Wheat, El Horno, Chapingo

Ricardo Rodríguez R., PASANTE, Research Aide, Wheat, El Horno, Chapingo
Federico Castilla Chacón, ING. AGR., in charge, Farinology Laboratory, Chapingo
Fidencio J. Nava S., CHEMIST, Research Aide, Farinology Laboratory, Chapingo
Clemente Vázquez G., ING. AGR., Investigator, Wheat, CIANO, Cd. Obregón
Manuel García C., ING. AGR., Investigator, Wheat, Mexicali
Andrés Martínez M., ING. AGR., Investigator, Wheat, Río Bravo
Máximo Rivera M., ING. AGR., Investigator, Wheat, Cd. Delicias
Vicente Zacarías D., ING. AGR., Investigator, Wheat, El Roque, Celaya
Arnulfo Gómez, ING. AGR., Investigator, Wheat, El Roque, Celaya
Manuel Navarro F., ING. AGR., Chief of Barley Improvement Section, INIA
Uriel Maldonado A., AGR., Investigator, Barley, El Horno, Chapingo
Enrique Riojas, ING. AGR., Investigator, Barley, CIANO, Cd. Obregón
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Silvestre Espino, ING. AGR., Chief of Rice Section, El Horno, Chapingo
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Manuel Pardo G., ING. AGR., Investigator, Rice, Zacatepec
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Agustín Ríos M., ING. AGR., Investigator, Rice, Culiacán
Neftalí Calixto Cruz, ING. AGR., Investigator, Rice, Cotaxtla
Aristeo Acosta, M.S. (on leave)
Evangelina Villegas, CHEMIST (on leave)
Gregorio Vázquez G., M.S. (on leave)
Alfredo García Sánchez, ING. AGR. (on leave)

VARIETAL IMPROVEMENT IN BEANS AND SOYBEANS

Alfonso Crispín M., PH.D., Head of Department, INIA
César C. Gallegos B., M.S., Investigator, El Horno, Chapingo
Tiburcio Martínez, ING. AGR., Investigator, El Horno, Chapingo
Celio Barriga S., M.S., Investigator, in charge, Soybean Improvement, CIANO, Cd. Obregón
David Alvarado A., PASANTE, Research Aide, Torreón
Eleno Muñoz M., ING. AGR., Investigator, Río Bravo
Edgar Larrea R., ING. AGR., Investigator, in charge, Bean and Soybean Improvement, El Roque, Celaya
Antonio García B., ING. AGR., Investigator, El Roque, Celaya
Miguel Arroyo A., ING. AGR., Investigator, Pabellón
Guadalupe Velo F., PASANTE, Research Aide, Cotaxtla
Graciano Patiño Méndez, M.S. (on leave)
Eugenio Martínez Salazar, M.S. (on leave)
Salvador Miranda Colín, ING. AGR. (on leave)
José Luis Serrano, ING. AGR. (on leave)

VARIETAL IMPROVEMENT OF POTATOES

Javier Cervantes Romo, PH.D., Head of Department, INIA
Santiago Delgado Sánchez, M.S., Assistant Head of Department, INIA
Edmundo Dávila G., M.S., Investigator, El Horno, Chapingo

Fernando Rulfo V., ING. AGR., Investigator, El Horno, Chapingo
Herminio Montelongo, ING. AGR., Investigator, El Horno, Chapingo
Mónika Bopp, M.S., Investigator, El Horno, Chapingo
Heliodoro Carreto, PASANTE, Research Aide, El Horno, Chapingo
Jesús Fernández B., ING. AGR., Investigator, El Horno, Chapingo
Ariel Rodríguez, M.S., Investigator, El Horno, Chapingo
Armando Campos Vela, ING. AGR. (on leave)
Gelacio Pérez Ugalde, ING. AGR. (on leave)
Rubén Merino Irigoyen, ING. AGR. (on leave)

HORTICULTURE

Eduardo Alvarez L., PH.D., Head of Department, INIA
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José Laborde, ING. AGR., Investigator, El Horno, Chapingo
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Hilda Mendoza, AGR., Investigator, El Horno, Chapingo
Ignacio Muñoz F., ING. AGR., Investigator, Culiacán
Martín Garatuza, ING. AGR., Investigator, Los Mochis
Víctor Nieto H., M.S., Investigator, General Terán
Guillermo Hernández Bravo, M.S., Investigator, El Roque, Celaya
Rafael Rodríguez M., AGR., Investigator, Pabellón
Juventino Contreras, ING. AGR., Investigator, Cotaxtla
Josué Kohashi Shibata, M.S. (on leave)

TROPICAL CROPS

Leonardo Cabrera V., ING. AGR., Investigator, Rosario Izapa
Bernardino Gómez B., ING. AGR., Investigator, Rosario Izapa
Jesús Marín R., ING. AGR., Investigator, Rosario Izapa
Jorge Soto R., ING. AGR., Investigator, Rosario Izapa

IMPROVEMENT OF FORAGE GRASSES AND LEGUMES

Roderic E. Buller, PH.D., Agronomist, The Rockefeller Foundation; Technical Advisor, INIA (to December, 1961)
Arturo Sánchez D., M.S., Head of Department, INIA
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Juan Oviedo L., ING. AGR., Investigator, Torreón
Fiacro Martínez Martínez, ING. AGR., Investigator, La Campana
Alberto Pérez G., ING. AGR., Investigator, La Campana
Héctor López L., PASANTE, Research Aide, La Campana
Pedro Sánchez de la C., M.S., Investigator, El Roque, Celaya
Mario Ferrer F., M.S., Investigator, Cotaxtla
Angel Ramos, PASANTE, Research Aide, Cotaxtla
Martín H. González Alanís, M.S. (on leave)
Ricardo Garza Treviño, M.S. (on leave)

VARIETAL IMPROVEMENT OF OILSEED CROPS

Leodegario Quilantán, M.S., Head of Department, INIA
Hugo Martínez, M.S., Investigator, El Horno, Chapingo
Baldomero Rodríguez, ING. AGR., Investigator, CIANO, Cd. Obregón
Mauricio Leyva, ING. AGR., Investigator, Culiacán
Raúl Robles S., ING. AGR., Investigator, Río Bravo
César Estrada M., AGR., Research Aide, Cd. Delicias
José García H., ING. AGR., Investigator, El Roque, Celaya
Oscar Gutiérrez, ING. AGR., Investigator, Antúnez
Juan Albarrán, ING. AGR., Investigator, Antúnez
Ricardo León Manzo, ING. AGR. (on leave)

VARIETAL IMPROVEMENT OF SUGAR CANE

Federico Sánchez N., PH.D., Head of Department, INIA
Reynaldo Luis Pineda, ING. AGR., Assistant Head of Department, INIA
Fernando Cabrera A., ING. AGR., Investigator, El Horno, Chapingo
Jaime Delgado H., ING. AGR., Investigator, Zacatepec
Alberto Corrales M., ING. AGR., Investigator, Zacatepec
Neftalí Guzmán M., CHEMIST, in charge, Laboratory, Zacatepec
Víctor Manuel Lamas, CHEMIST, Research Aide, Zacatepec
Silverio Flores Cáceres, M.S. (on leave)

VARIETAL IMPROVEMENT OF COTTON

Luis Equihua H., ING. AGR., Head of Department, INIA
Ernesto Samayoa, PASANTE, Research Aide, El Horno, Chapingo
Gilberto Ortiz B., ING. AGR., Investigator, CIANO, Cd. Obregón
Fermín Hernández, ING. AGR., Investigator, CIANO, Cd. Obregón
Felipe Millán P., ING. AGR., Investigator, Culiacán
Juan Moreno M., ING. AGR., Investigator, Mexicali
Ricardo Prado, ING. AGR., Investigator, Torreón
Horacio Escobar, ING. AGR., Investigator, Torreón
Oscar García, PASANTE, Research Aide, Río Bravo
Arnoldo Barragán, ING. AGR., Investigator, Cd. Delicias
Antonio Coronado, ING. AGR., Investigator, Rosario Izapa

RUBBER

Angel Vergara Castillo, ING. AGR., Head of Department, INIA
Victorino Regalado, ING. AGR., Investigator, El Palmar
Rubén García S., ING. AGR., Investigator, El Palmar
Leonel Bobadilla, ING. AGR., Investigator, El Palmar
Ramiro Porter, ING. AGR., Investigator, El Palmar

SOIL FERTILITY

Reggie J. Laird, PH.D., Soil Scientist, The Rockefeller Foundation; Technical Advisor, INIA
Rodolfo Moreno D., PH.D., Head of Department, INIA
Enrique Ortega T., PH.D., Assistant Head of Department, INIA
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Rodolfo Vera y Z., PASANTE, CHEMIST, Research Aide, El Horno, Chapingo
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Consuelo Vázquez G., CHEMIST, Research Aide, El Horno, Chapingo
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Efrén Guerrero O., PASANTE, Research Aide, Mexicali
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Jorge Alarcón, PASANTE, Research Aide, Río Bravo
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Ignacio Navarro, ING. AGR., Investigator, El Roque, Celaya
Fernando Coronel T., ING. AGR., Investigator, Cotaxtla
Raymundo Huerta N., ING. AGR., Investigator, Cotaxtla
Gildardo Carmona Ruiz, ING. AGR. (on leave)
Jesús Moncada de la Fuente, M.S. (on leave)
Alfredo Echegaray Alemán, M.S. (on leave)
Fidencio Puente Flores, M.S. (on leave)

INSECT PESTS AND THEIR CONTROL

William R. Young, PH.D., Associate Entomologist, The Rockefeller Foundation; Technical Advisor, INIA (to January, 1962)
Alejandro Ortega Corona, PH.D., Entomologist, Head of Department, INIA
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Raúl Muñiz, BIÓLOGO, Investigator, El Horno, Chapingo
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Jesús Ambriz P., ING. AGR., Investigator, Torreón
Leopoldo Herrera, ING. AGR., Investigator, Río Bravo
Hermenegildo Velazco, ING. AGR., Investigator, El Roque, Celaya
Gonzalo Granados R., PASANTE, Research Aide, Cotaxtla
Celestino Morán V., ING. AGR., Investigator, Antúnez
Jesús Mario de la Fuente V., M.S. (on leave)
Juan Antonio Sifuentes A., M.S. (on leave)
Juan Villanueva Barradas, ING. AGR. (on leave)

PLANT PATHOLOGY

Antonio Rodríguez, PH.D., Head of Department, INIA
Santiago Fuentes F., M.S., Assistant Head of Department, INIA
Sebastián Romero, M.S., Investigator, *Phytophthora*, El Horno, Chapingo
Héctor Rodríguez S., BIOCHEMIST, Investigator, Cotton Diseases and Bacterial Physiology, El Horno, Chapingo
Ma. de Lourdes de la Isla, M.S., Investigator, Stored Grains and Plant Disease Identification, El Horno, Chapingo
Jesús Castro, PASANTE, Research Aide, El Horno, Chapingo
Elena Fourton, PASANTE, BIOLOGIST, Research Aide, El Horno, Chapingo
Luis César López, M.S., Investigator, El Horno, Chapingo
Héctor León Gallegos, M.S., Investigator, El Roque, Celaya
Carlos de León, ING. AGR., Investigator, Cotaxtla
Jorge Galindo Alonso, M.S. (on leave)
Daniel Téliz Ortiz, ING. AGR. (on leave)

WEEDS AND THEIR CONTROL

Omar Agundis Mata, M.S., Assistant Head of Department, INIA
Benjamín Castillo A., ING. AGR., Investigator, El Horno, Chapingo
Andrés Valtierra, ING. AGR., Investigator, Cotaxtla
Jorge Nieto Hatem, M.S. (on leave)

SEED LABORATORY

Daniel Guerrero Z., M.S., Head of Laboratory, INIA
Federico Alvarez G., PASANTE, Research Aide, El Horno, Chapingo

BIOMETRY

Carlos Meza R., ING. AGR., Assistant Head of Department, INIA
José F. Garcés, PASANTE, Research Aide, El Horno, Chapingo
Ernesto Gallegos, PASANTE, Research Aide, El Horno, Chapingo

POULTRY

John A. Pino, PH.D., Animal Scientist (Poultry), The Rockefeller Foundation; Head of Department, INIA; Director, National Center of Livestock Research, Palo Alto, D.F.
Manuel Cuca García, M.S., Investigator, Poultry Nutrition, El Horno, Chapingo
Ricardo Daniels Borboa, PASANTE, Research Aide, Santa Elena, Toluca
Carmen Mendoza, PASANTE, CHEMIST, Research Aide, El Horno, Chapingo
Sergio Brambila, M.S. (on leave)
Augusto Aguilera Amezcua, M.S. (on leave)
Edsel J. Bixler, ING. AGR. (on leave)
Gustavo Reta P., D.V.M. (on leave)

VETERINARY MEDICINE

Daniel D. Hagen, D.V.M., Associate Animal Pathologist, The Rockefeller Foundation; Head of Department, INIA; Head, Department of Animal Pathology, National Center of Livestock Research, Palo Alto, D.F.

Alejandro Cuadra, D.V.M., Investigator, Poultry Pathology; in charge, Diagnostic Laboratory, Santa Elena, Toluca

Ana María Lara F., BIOCHEMIST, BACTERIOLOGIST, Research Aide, Poultry Pathology, National University of Mexico

Celedonio Garrido M., D.V.M., Investigator, National University of Mexico

Sergio Pinzón G., D.V.M., Investigator, National University of Mexico

Augusto Mancisidor, D.V.M., Investigator, Faculty of Veterinary Medicine, University of Veracruz

Eduardo Rivera Cruz, M.D. (on leave)

Pedro Solana Martagón, M.D. (on leave)

ANIMAL NUTRITION

Ned S. Raun, PH.D., Associate Animal Scientist, The Rockefeller Foundation; Technical Advisor, INIA; Head, Department of Animal Nutrition, National Center of Livestock Research, Palo Alto, D.F.

Carlos Tapia Jasso, M.S., Head of Department, INIA

Manuel Casas, PASANTE, Research Aide, Mexico

Héctor Merino, PASANTE, Research Aide, Mexico

Marcial Velasco, M.S., Investigator, La Campana

Carlos López de la G., ING. AGR., Investigator, La Campana

Candelario Carrera, M.S., Investigator, Cotaxtla

AGRICULTURAL ECONOMICS

Donald K. Freebairn, PH.D., Associate Agricultural Economist, The Rockefeller Foundation; Head of Department, INIA

José S. Silos, M.S., Investigator, Production Economics

Manuel Gollás Q., PASANTE, Research Aide, Production Economics

Vicente González R., PASANTE, Research Aide, Production Economics

Héctor José Silva, PASANTE, Research Aide, Production Economics

Mateo Vázquez, PASANTE, Research Aide, Production Economics

Francisco Jacinto Andrade, ING. AGR. (on leave)

José Soto Angli, ING. AGR. (on leave)

AGRICULTURAL INFORMATION

Delbert T. Myren, PH.D., Associate Information Specialist, The Rockefeller Foundation; Head of Department, INIA

Neil B. MacLellan, Staff Photographer, The Rockefeller Foundation

Mario Gutiérrez Jiménez, ING. AGR., Information Specialist

Leobardo Briseño Terpán, Assistant Chief of Photographic Laboratory

Gregorio Martínez V., M.S., Information Specialist
Felipe Rodríguez C., ING. AGR., Assistant Information Specialist
Rubén Hermesdorf, ING. AGR., Assistant Information Specialist
Abdo Magdub, ING. AGR., Assistant Information Specialist, CIANO, Cd. Obregón
Víctor Lara Flores, ING. AGR., Assistant Information Specialist, Cotaxtla
Alfonso Ortega A., PASANTE, Research Aide in Publications
Jesús Martínez Reding, PASANTE, Research Aide in Publications
Juan Zamora López, Laboratory Technician
Isidro Castro Valencia, Artist
Miguel Angel Ortega, Artist
David Sepúlveda, Artist
Leobardo Jiménez Sánchez (on leave)
Gil Olmos Barrera (on leave)
Rodolfo Chena González, M.S. (on leave)

LIBRARY

Pablo Velásquez, M.S., in charge, Library, INIA
Ramón Nadurille, PASANTE, Research Aide

MAINTENANCE AND DEVELOPMENT

Ramón G. Jasso, ING. AGR., Head of Department, INIA

CONSTRUCTION

Roberto Peregrina, ING. AGR., Head of Department, INIA
Sergio Romero, ING. TOPÓGRAFO
Jesús Paredes V., ING. TOPÓGRAFO

Experimental cattle feedlot facilities, Cotaxtla.

Director's Introduction

The early portion of the year's activities being reported represented a continuing period of adjustments within the National Institute of Agricultural Research (Instituto Nacional de Investigaciones Agrícolas—INIA).

The new organization has faced the multiple problems of coordinating all aspects of agricultural research in the Republic, from food to fiber crops, of developing and clarifying procedures, of realigning the experiment station system, and of continuing the principal productive lines of research.

This period has been one of drastic revision in the experiment station system, involving the reduction in number of stations and release of personnel. These steps were largely dictated by financial pressures which continue to limit total research programs of the organization.

A coordination of activities on a national scale brought about by reorganization has involved development of new mutual understandings with outside agencies as well as within the structure itself.

While this period of adjustment has consumed much time and energy, it is significant that research and experimentation have continued to provide information and new techniques useful in the advancement of Mexican agriculture.

The character of a new organization is evolving which must be capable of effectively resolving national agricultural problems through the application of the scientific approach. Additional responsibility for the development of research programs was assumed by capable Mexican personnel during the course of the year. This represents further progress in the transfer of responsibility and replacement of Rockefeller Foundation staff, releasing them for duties in other countries or other phases of the agricultural program.

During late 1961 it became apparent that some modification in structural organization would be essential in order that the animal science research projects might develop effectively and provide the information which is urgently needed to advance the livestock industry of Mexico. This conclusion was based on financial as well as organizational considerations within the Ministry of Agriculture.

In May, 1962, Minister of Agriculture Julián Rodríguez Adame established the National Center of Livestock (Zootecnia) Research within the framework of the National Institute of Livestock (Pecuaria) Research, with headquarters at Palo Alto, D.F. This action, together with other significant modifications in the organizational structure of the Subsecretariat of Livestock, places new emphasis on research activities in this branch of the Ministry. The work programs and personnel of three sections of INIA involved in the cooperative program—poultry husbandry, animal pathology, and animal nutrition—were transferred to Palo Alto immediately. Physical installations on INIA stations continue active through cooperative arrangements between these two organizations, with responsibility for conduct of research and experimentation now resting solely with the National Center of Livestock Research.

The Minister's action in establishing the National Board of Agricultural Consultants and the National Board of Livestock Consultants during this year has been welcomed by the research institutions and by the agricultural and livestock industries as a highly constructive step in developing closer liaison for the benefit of all. The development of closer working relationship between research programs or institutions and the private interests they serve should result in increased support for research and a clearer understanding of national problems.

NATIONAL SCHOOL OF AGRICULTURE AND GRADUATE SCHOOL, CHAPINGO

In an environment of continuous quest for improvement and strengthening of agricultural education, the directorship of both institutions was changed during this year. On January 22, 1962, the Minister of Agriculture appointed Dr. Basilio Rojas Director of the Graduate School, and on May 14 he named Dr. Marcos Ramirez Genel Director of the National School of Agriculture. These men bring to their respective posts rich backgrounds of excellent training and years of experience in research and teaching, as well as great enthusiasm for the schools and a dedication to the advancement of agricultural education.

Continued Rockefeller Foundation support to the Graduate School during the year, both economic and technical, has assisted in maintaining a dynamic rate of development. Professorial staff has been strengthened, 30 students are now enrolled, and 10 will complete course requirements during 1962 for the M.S. degree.

With the initiation of an ambitious series of summer school courses, it will now be possible for research personnel and professors of agricultural schools in Mexico to register for courses during the summer sessions and accumulate the required residence and credits for advanced degrees without unduly disrupting research or teaching programs of their respective insititutions.

Direct participation in teaching and counseling activities of both schools at Chapingo by staff of INIA is being continued. It is expected that this participation will expand in the future, thereby contributing to closer personal and professional relationships of mutual benefit.

During the week of May 7, 1962, the Second Symposium of Agricultural Research was held at the National School of Agriculture, jointly sponsored by the School and INIA. More than any other single event this symposium serves to demonstrate the growing interest in Mexico in scientific advancement and the demonstration of accomplishments in agricultural research. It is significant that 24 institutions participated in this symposium as compared with 8 in the first symposium held in November, 1958. A total of 190 papers were presented either in open sessions or at round-table discussions, as against 39 in 1958.

GENERAL ACTIVITIES

The addition to the staff of Dr. Ned S. Raun on August 1, 1961, signaled the initiation of nutritional research with large animals. Projects in this vital area will complement the animal science program, which has been advancing rapidly over the past years in poultry husbandry, animal pathology, and forage utilization and range management.

On November 1, 1961, Dr. William H. Hatheway transferred from Colombia to Mexico as a staff member of the expanding Inter-American Food Crop Improvement Program.

During the year being reported the Mexican Agricultural Program lost three of its staff members. On December 14, 1961, Dr. Roderic E. Buller resigned to accept a position with the Peace Corps in Venezuela. The results of his years of research in this program have established a firm basis for expanding investigation in forage crops and animal nutrition in Mexico.

On December 22, 1961, Dr. William R. Young joined the Indian Agricultural Program. Because of the excellent training program in entomology which Dr. Young and other staff have conducted in Mexico over the years, there has been no loss of continuity of research projects within INIA. Dr. Young's responsibilities have been taken over by Dr. Alejandro Ortega.

On March 31, 1962, Dr. Douglas Barnes resigned from the Mexican program to accept a position with an agricultural products concern in Mexico City. His years of service in both research and administration have been of great assistance.

TEMPORARY STAFF AND SCIENTIFIC AIDES

The program was strengthened during the past year by the assistance of four temporary scientific aides. Dr. J. B. Peterson, Head, Department of Agronomy, Purdue University, reviewed agronomy projects and research techniques with staff in Mexico during the last 10 days of a three-month assignment which included the Chilean and Colombian programs.

Dr. A. A. Beetle, Professor of Range Management, University of Wyoming, concluded a six-month appointment in May, 1962. During this time Dr. Beetle was assigned to the School of Agriculture and Livestock, Technological Institute and School of Advanced Studies of Monterrey, where he collaborated with staff in studying browse range vegetation in the Nuevo León area, presented a graduate-level course in the botany and ecology of range vegetation, and advised graduate students and professors on research projects.

Mr. S. C. Orr, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C., served with the program for five weeks in early 1962, during which time he gave valuable assistance in reviewing building plans for the National Research Center at Chapingo.

Dr. Albert E. Longley, cytogeneticist of Columbia, Missouri, was reappointed a Special Temporary Scientific Aide for a period of six months beginning May 15, 1962. Dr. Longley will continue his study of Mexican and Central American maize germ plasm as well as reinforce the plant breeding courses at the Graduate School.

VISITORS ON ROCKEFELLER FOUNDATION TRAVEL GRANTS

Ing. Antonio Bacigalupo, Head, General Institute of Research and Advanced Studies, Agrarian University, Lima, Peru.

Professor Antonio Vieira Machado, School of Veterinary Medicine, Rural University of the State of Minas Gerais, Belo Horizonte, Brazil.

Dr. Edgardo J. Trein, Faculty of Agronomy and Veterinary Medicine, University of Rio Grande do Sul, Pôrto Alegre, Brazil.

Dr. Richard R. Nelson, Plant Pathologist, North Carolina State College, Raleigh.

Ing. Benjamín Quijandría, Assistant Director of Investigations, Ministry of Agriculture, Peru.

Dr. Frederick N. Andrews, Head, Department of Animal Sciences, Purdue University, Lafayette, Indiana.

Ing. Guillermo Merino, in charge of corn improvement project at the Faculty of Agronomy, Central University, Quito, Ecuador.

Mr. Philip M. Sherlock, Vice Principal, University College of the West Indies, Trinidad, W.I.

Mr. Samai Charoenratha, Chief of the Division of Research and Agricultural Experiment Stations, Ministry of Agriculture, Bangkok, Thailand.

Ing. Carlos Vidalón, Dean, Faculty of Agricultural Engineering, Agrarian University, Lima, Peru.

Dr. Derek H. Lapwood, Plant Pathology Department, Rothamsted Experimental Station, Harpenden, England.

Dr. A. J. Ullstrup, Department of Botany and Plant Pathology, Purdue University, Lafayette, Indiana.

PARTIAL LIST OF OTHER VISITING SCIENTISTS

Dr. John T. Middleton, Chairman, Department of Plant Pathology, University of California, Riverside and Los Angeles.

Dr. Geraldo da Rocha, Head, Animal Nutrition Center, Department of Animal Production, State of São Paulo, Brazil.

Mr. Donald G. Fletcher, Executive Vice President, Crop Improvement Council, Minneapolis, Minnesota.

Ing. Omar Garrido V., Dean, Faculty of Agronomy, University of Venezuela, Maracay.

Dr. H. M. Beachell, Agronomist, Rice Experiment Station, U.S.D.A., Beaumont, Texas.

Ford Foundation Mission composed of Dr. John D. Millett, President of Miami University, Oxford, Ohio; former Ambassador Walter Howe; Prof. Sidney W. Mintz of Yale; and Mr. James F. Tierney of the Ford Foundation's International Training and Research Program.

Dr. James L. Morrill, Director of the Latin-American Program of the Ford Foundation.

Dr. Raymond A. White, Point IV, Accra, Ghana.

Dr. Omer W. Herrmann, Deputy Administrator, Agricultural Marketing Service, U.S.D.A., Washington, D.C.

Ing. Carlos Ochoa, Agricultural Research and Promotion Service, Ministry of Agriculture, Lima, Peru.

Mr. Glenn A. Goldsmith, Director of Research, Pan-American Seeds, Inc., Paonia, Colorado.

Dr. A. R. Midgley, Chairman, Agronomy Department, University of Vermont, Burlington.

Dr. R. B. Stewart, Vice President and Manager of Purdue Research Foundation, Lafayette, Indiana.

Dr. Philip A. Miller, Chief of the North Carolina State College Mission at Lima, Peru.

Dr. O. S. Aamodt, University Park, Hyattsville, Maryland.

Dr. Charles R. Davenport, Chief, Western Hemisphere Analysis Branch, Regional Analysis Division, Economic Research Service, U.S.D.A., Washington, D.C.

Mr. A. G. Davis, Head of the Department of Agriculture, Faculty of Sciences, University College of Rhodesia and Nyasaland, Salisbury.

Dr. R. G. Lambert, Department of Plant Pathology and Botany, University of Minnesota, St. Paul.

Mr. Eugene B. Hayden, Secretary, Crop Quality Council, Minneapolis, Minnesota.

Dr. Ray F. Smith, Chairman, Department of Entomology and Parasitology, University of California, Berkeley.

Dr. G. K. Maliphant, Faculties of Agriculture and Engineering, University College of the West Indies, Trinidad, W.I.

Dr. John G. Martland and Mr. Thomas Mangan, Agricultural Research Department, Green Giant Company, Le Sueur, Minnesota.

REVIEW OF THE AGRICULTURAL YEAR

Improved production practices resulting from greater diffusion and acceptance of recommendations affecting the many controllable factors which can increase yields are principally responsible for the satisfactory corn crop of approximately 5,900,000 tons in 1961. This increase was brought about in spite of drought conditions in vast areas of nonirrigated production. A new national goal of between 7.5 and 8 million tons by 1964 has been established by the Minister of Agriculture. The newly initiated Veracruz-Chiapas plan to increase corn yields in these states to 1,145,000 tons and the successful Jalisco plan are steps in reaching this new national goal. Prospects for this year's corn crop appear good and production may exceed 6 million tons.

Basic food crop production in 1961 reached generally satisfactory levels. Cotton production totaled about 2 million bales, down slightly from the 1960 total. It is significant that emphasis continues on expansion of crop insurance and crop production credit. This last item particularly is intimately related to total crop production in Mexico and is a prime factor in influencing future production of any commodity or fiber.

While the above-mentioned crop production results have aided in general economic development, the total picture is not uniformly bright. Mexico is currently involved in one of the most serious recession periods of the past 16 years. It is evident that agriculture and industry must contribute more substantially to national development in order that a satisfactory rate of progress may be achieved.

Considerable significance is being attached in some quarters to studies which indicate that 40% of Mexico's gross national product was derived last year from industrial sources. This trend toward greater industrialization is being accomplished without impairing agricultural productivity.

It should be pointed out that the National Institute of Agricultural Research, as indicated in the Personnel section, is engaged in research and investigation in numerous fields in addition to those reported here. The Cooperative Agricultural Program, however, has since its inception been engaged in projects on the basic food crops and closely allied disciplines. With the reorganization of agricultural research and establishment of INIA, increased national attention is being given to tropical crops (cocoa), sugar cane, oilseed crops, biometry, cotton, and climatology. It should be noted that total program efforts also involve the basic departments of Maintenance and Experiment Station Development, and Construction.

SUMMARY OF RESEARCH RESULTS

The progress reviewed in this report corresponds to the September, 1961—August, 1962 crop year.

CORN

Commercial corn production in Mexico during 1961 is estimated at about 10% above that of the previous year in spite of severe drought losses in certain areas. Research programs resulting in improved varieties and cultural practices continue to advance the production of this basic cereal.

The two hybrids H-412 and H-507, released during 1960, were produced commercially on sizable acreages with excellent results. Additional efforts must be made in the production and distribution of improved seeds to insure that farmers can obtain adequate quantities of high-quality seed of the varieties that have been released.

Corn is gaining as a cash crop in certain irrigated areas where cotton acreage is being reduced, for example in the Matamoros area on the Texas border. As part of the general expansion of the program in 1961, work was begun on developing a hybrid suitable for this area using lines of H-412. While H-412 itself performed very well in this area, additional development is needed before firm varietal recommendations can be made.

A major effort was made to integrate breeding materials of the two previous agencies into a single program, and vast numbers of collections, varieties, lines, and hybrids were compared.

SORGHUM

Grain sorghum production increased substantially in Mexico during 1961. This cereal is a valuable supplement to corn and is steadily gaining in acceptance for use in animal feeds.

Additional collections from the higher elevations of Ethiopia were obtained in an intensified effort to develop suitable grain and forage types for the central plateau of Mexico. Three previous selections from this program were widely tested during 1961 and demonstrated excellent possibilities for use as both grain and forage. Plantings of commercial size are planned for 1962.

Crosses of the new African introductions to genetic stocks for early maturity, dwarf plant, and male sterility factors are the beginning of an expanded sorghum program for higher elevations. For the first time, breeding material is available that appears to offer real promise for major advances in this region.

WHEAT

During the past ten years the national average wheat yields have more than doubled, increasing from about 900 kg./ha. in 1952 to an estimated 1,900 for the 1962 harvest. More than 95% of the crop just harvested was made up of improved varieties. Lerma Rojo continues to account for the greater portion of the wheat acreage, but the new, high-yielding, lodging-resistant varieties Nainari 60, Pitic 62, and Penjamo 62 contributed greatly to the latest increase.

Seven new varieties have been selected on the basis of their performance during the past two years and are being increased. All seven will yield as much as or more than Pitic 62 and Penjamo 62. Three are varieties of soft texture and similar in milling and baking characteristics to Lerma Rojo. The other four are high-yielding dwarf wheats with red grain of hard texture, medium-strong to strong dough properties, and good baking characteristics.

The program initiated several years ago to obtain leaf-rust-resistant varieties began to bear fruit this year. Among the crosses made to carry the Chinese Aegylops resistance directly into Mexican dwarf lines, several F_4 lines were found which are homozygous for their immunity to leaf rust. Using these early maturing, dwarf, leaf-rust-immune lines as parents, it will be very easy to transfer the leaf-rust immunity to commercial dwarf wheats having good milling and baking characteristics and high yields.

The program to produce a dwarf durum wheat variety combining high yield with good quality for spaghetti production has progressed to the point where seed increase will be started on the first variety during the coming year.

Although the wheat-producing areas of the Bajío and the Northwest will be able to produce sufficient wheat to satisfy Mexico's needs for the immediate future, experimental plantings were made during the past year in northwestern Chihuahua and northern Tamaulipas.

OATS

Approximately 90,500 hectares of oats are planted in Mexico with an average yield of only 700 kg./ha. The principal variety, Burt, which was introduced from Kansas some 42 years ago, has at least three important weaknesses: susceptibility to stem rust, inadequate quality for the oats industry, and relatively low yield. As a first step to solving these problems, many oat introductions have been made, mainly from the United States. Several of these are superior to Burt and will be released to farmers this year. A crossing program is also being initiated to combine the good characteristics of several of the oats which were studied, such as earliness, short stiff straw, high yield, and good quality.

BARLEY

In the past five years average barley yields in Mexico have increased from 750 to 2,400 kg./ha., owing in part to the replacement of native mixed varieties by the improved varieties, Toluca I and Vantage. In yield trials at CIANO and in the Bajío during the past year, however, a number of experimental lines outyielded these two varieties by 20% to 60%. The best line is being increased during the summer of 1962 for release to farmers.

A barley quality laboratory is being planned for quality testing of individual plants as early as the F_2 or F_3 generation; this will save considerable work and expenditure in handling of segregating lines.

BEANS AND SOYBEANS

In continuing research on improvement of these crops, 15 new races of bean rust, *Uromyces appendiculatus*, were identified in 1961, bringing the total of races known in Mexico to 31. In addition, six new races of bean anthracnose were identified last year.

It has been demonstrated that fungicidal treatment of seeds can effectively protect beans from *Rhizoctonia solani*, the principal causal organism of root rots in the northern bean-producing regions. This practice, however, is not yet widely accepted by farmers and will therefore have only a slight effect on bean production in the immediate future.

Selection programs for resistance to bean rust, increased yield, and other desirable agronomic characteristics have been extended to all principal bean-growing areas.

Soybean production may be increased in the future through development of a more productive and more widely adapted variety. Work with existing varieties and lines has shown that yield potential and adaptation to a longer planting season are definitely limited in material presently available.

POTATOES

During the past year, several new collections have been added to the potato germ plasm bank, and studies on foliage and tuber resistance to late blight have uncovered varieties showing both characteristics. Two new commercial potato varieties have been selected from 10,000 clones planted in the Toluca Valley under severe blight conditions. Additional research is in progress relating to the effect of Virus X disease of potatoes on tuber yield, and efforts are being made to combine late and early resistance characteristics in the same variety.

HORTICULTURE

Horticultural investigations, devoted principally to vegetable crops, continue to emphasize varietal adaptation, selection, and genetic improvement of varieties for the principal agricultural regions of Mexico. Particular emphasis is placed on quality characteristics in order to improve market acceptance. Since vegetables form a most important part of the daily diet, investigations relating to home garden production continue to receive maximum attention.

Evaluation of new foreign introductions provided information for modification of varietal recommendations for the high plateau and Bajío regions.

Peppers (principally pungent types) are one of the three most important vegetables with regard both to economic value and quantity consumed in the diet. New varieties and improved lines are being released for the high plateau and Bajío regions which combine resistance to root rot and greater uniformity of product with higher yields.

SOIL FERTILITY AND MANAGEMENT

Soil management studies leading to the application of economically advantageous practices by farmers continue to yield valuable benefits to Mexican agriculture. The judicious use of chemical and organic fertilizers of the right kind and amount can result in greatly increased yields of corn, as shown by studies in the State of Veracruz. Irrigation practices based on estimated moisture requirements according to soil properties proved to be precise, but additional refinements are needed. The effect of cropping systems on soil properties and subsequent yields has demonstrated the importance of management practices as related to specific crops and crop sequence.

ENTOMOLOGY

This program has the following objectives: (1) identification of the factors which determine the incidence of insect pests as well as fluctuations in populations, (2) estimation of the economic importance of the losses caused by different insects, (3) selection of plant materials resistant to insect attack, (4) evaluation of insecticides, and (5) description of the biology of pests in order to develop adequate control methods.

Some important results which have been derived from these studies during the past year are as follows:

In order to reduce damage from the pink bollworm, *Pectinophora gossypiella* Saund., in the La Laguna region, cotton plantings should be made during the first two weeks of April.

Experiments at CIANO showed that an early attack of the boll weevil, *Anthonomus* sp., and the bollworm, *Weliottus* sp., at levels that damaged 20%, 40%, and 60% of the squares and bolls, reduced yields by 0%, 7%, and 23%, respectively; a late attack at the same damage levels caused yield reductions of 17%, 27%, and 31%, respectively. This type of information is making it possible to decide at what level of infestation chemical control is justified, and thus to avoid unnecessary applications which greatly increase the costs of production.

In a cooperative project at El Horno with the potato section the application of granulated thimet (3.0 kg./ha.) before planting reduced the incidence of the virus disease, purple top, by 66%; this resulted in a 28% yield increase and was associated with a reduction in population of several sucking insects.

Studies of the life cycle of the Mexican bean beetle have provided basic information for studies now under way which involve the liberation of insects sexually sterilized by means of gamma radiations.

PLANT PATHOLOGY

The research workers of the plant pathology section have encountered new plant disease problems to add to those already a menace to crop production. A fungus which affects corn kernels apparently has become more common in Mexico. Varying degrees of plant resistance to tassel and head smut disease have been shown. Similarly, in relation to corn stunt disease and leaf blight, variability of resistance of some new and some common corn lines was shown. A fungus infection of wheat known as "black point" caused considerable alarm among the wheat farmers; however, control measures apparently are effective against this disease.

HERBICIDES

In the Gulf tropics, where most of the herbicide work is being conducted, it has been found that the critical period of weed competition for corn and beans is during the first 30 days after planting. In rice, the results of the first year of study show that uncontrolled weed competition during the first 20 days nearly eliminates the rice stand.

For the control of weeds in corn, a large number of herbicides have been tested; the most economical method found up to now is the combination of mechanical cultivation with pre-emergence applications of simazin, 2,4-D, or the mixture of 2,4-D and DNBP in 30-cm. bands over the row.

A bioassay test to determine the rate of disappearance from the soil of 2,4-D and simazin showed a rather rapid disappearance, as might be expected on tropical soils. 2,4-D at 4 kg./ha. disappeared almost completely in 20 days; simazin at the same rate stayed toxic enough to reduce about 50% of the stand and growth of sesame for about 40 days. There is apparently an adequate margin of security when susceptible crops follow corn in a rotation plan.

In bean trials during the past two years, one with scanty and one with ample rainfall, Amiben gave the best control without damage to the beans. In either granular or liquid form it almost completely eliminated mono- and dicotyledonous weeds for over 30 days. In 1961 STAM F-34 gave the best weed control in rice.

In potato weed control experiments in the Valley of Mexico, simazin, atrazine, and high rates of monuron gave effective control of annual weeds, but caused severe damage to the crop which was reflected in reduced yields.

POULTRY

The commercial poultry industry of Mexico, faced with the necessity of increasing efficiency of production, is being transformed from a system of small enterprises to an integrated activity. Many small hatcheries and feed mills have ceased to operate. On the other hand, an unusually large number of requests for assistance in feed formulation have been handled by the poultry section staff.

It has been demonstrated that the rural or backyard flock should not be replaced by "highly bred" chickens unless adequate management can be provided. Management practices still hold the key to a successful poultry enterprise. Intensive work on methods of reducing feed costs has continued, with promising results. A noteworthy achievement is the research dealing with pigmentation of egg yolks and skin of poultry. In the near future poultry diets will include flower petal meal produced from the Aztec marigold as an efficient and economical source of xanthophyll.

An efficient method of rearing future breeding turkeys on pasture gave promising results in the first year and is being further explored.

ANIMAL PATHOLOGY

As the size of poultry operations increases, management problems multiply, thus setting the stage for disease complications. Although most poultry losses are attributable directly to a poultry disease, indirectly the basic problems in Mexico stem from poor management practices. The presence of an immunologically distinct form of Newcastle disease virus, the appearance of laryngotracheitis, and the apparent presence of infectious bronchitis all complicate the respiratory disease complex. Accurate differential diagnosis is now more important than ever.

The mastitis studies in commercial dairy herds have continued and show that through a rigidly followed sanitary program milk production is increased considerably. Reproductive problems of dairy cows are being classified throughout complete cycles to determine their relative importance.

A well-equipped microbiological research laboratory has been completed at the Veterinary School of the National University as a cooperative effort with The Rockefeller Foundation. Active research and training projects in this new facility have been initiated.

ANIMAL NUTRITION

The addition of a new staff member to the Mexican Agricultural Program in the field of animal nutrition signifies the initiation of research projects in one of the most important aspects of animal production. The per capita consumption of beef, pork, sheep, and goat, already at low levels, coupled with a rapidly expanding human population, makes it urgent to develop methods for more rapid and efficient production of meat and milk. Current antiquated practices, which for example require five to six years before a steer reaches market size, must be replaced by new technology. Probably the most rapid strides can be achieved through the application of feeding techniques based upon sound nutrition principles. The broad goal of the animal nutrition program is to study how best to utilize the available nutrient materials to increase animal production economically.

Several feed lot trials with steers have already been realized. The value of safflower meal as a nitrogen source for cattle was effectively demonstrated. This and other experiments are paving the way for cattlemen to follow. Research has been started on the nutrition of range cattle particularly as it affects reproductive performance.

AGRICULTURAL ECONOMICS

The work in agricultural economics continues to emphasize farm production economics in both the private and *ejidal* sectors. One of the fundamental objects of the field studies has been to provide knowledge that will help those who have control over farm resources to use them more effectively. Data from field studies in northwest Mexico have been used to develop a farm business analysis chart for this region. On this chart farmers, extension agents, and agricultural credit managers may compare the performance of a given farm with standards established for the region for the purpose of evaluating objectively the critical management factors under control of the farm operator.

One of the projects under way in the *ejidal* sector includes the study of collective societies in the Yaqui Valley of Sonora. A critical evaluation of these societies indicates that there are serious weaknesses in organization and management as is indicated by low productivity of land and capital. Opportunities for alternative systems of organization are being evaluated and these in turn will be considered in terms of the institutional parameters which limit the forms of *ejidal* organization in the area.

AGRICULTURAL INFORMATION

During the past year information activities have increased as a consequence of the expanded program of INIA.

The series of technical bulletins and research reports has been continued, as well as the journal *Agricultura Técnica en México*.

The INIA has also continued to cooperate with the Office of the Director General for Agriculture in the publication of bulletins for the extension series, containing concrete recommendations on improved varieties or cultural practices for different areas in Mexico. A publication especially edited for horticultural farmers has completed its sixth year; a calendar for these specialized farmers in the Bajío area has also been produced. The regional publications, which contain specific information about recommended agricultural practices adapted to certain areas, have been modified according to the new organization of regional centers.

One of the most significant accomplishments during the past year has been the operational organization of the Publications Committee of INIA.

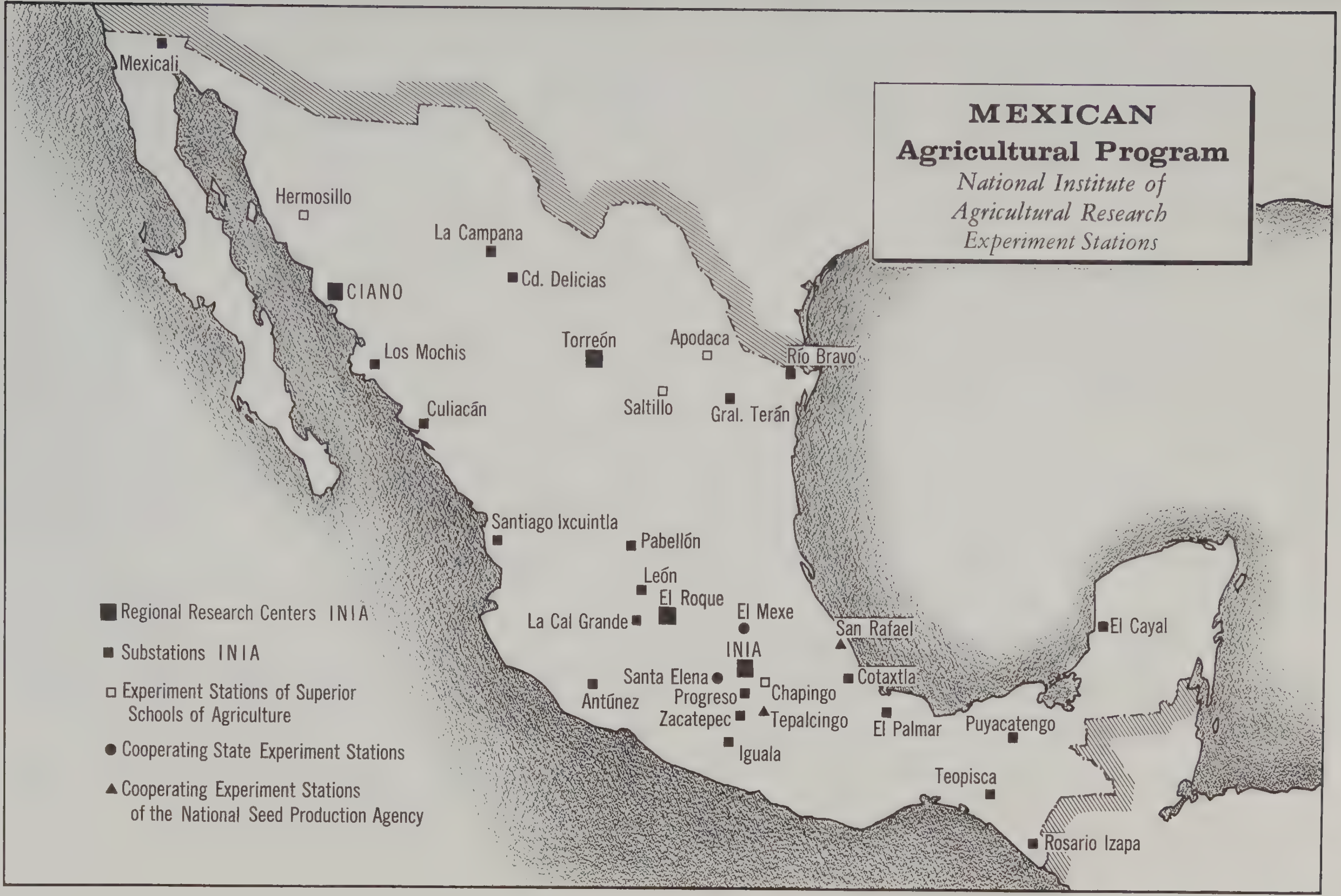
Activities involving the distribution of publications, filling of information requests through mail, and cooperation with the press, radio, and television, expanded during the year. At Cotaxtla the agricultural information program serving the Gulf tropics has been conducted successfully. A similar program has been started at CIANO to serve the important agricultural area of the Northwest.

Field days had a larger attendance than in previous years. Ten such events proved especially rewarding as a means of stimulating closer contacts between large numbers of farmers, research technicians, and extension agents from different parts of the country. The department also cooperated in 11 agricultural fairs held in different cities of Mexico.

Three new educational movies were produced this year and are being shown extensively in many small communities. This makes a total of 16 movies produced to date.

LIBRARY

The collection of bibliographic material was enriched considerably during the past year through acquisition of over 2,000 items. With the expanding animal science program and the general increase in agricultural research since reorganization, these materials are proving indispensable aids in the development of sound research programs. This is illustrated by the fact that over 11,000 reference articles or books were consulted by over 5,000 individuals during the past year. The library staff has participated actively in regional and international meetings which are stimulating the development of this science in Latin America.



MEXICAN
Agricultural Program
National Institute of
Agricultural Research
Experiment Stations

Experiment Stations of the National Institute of Agricultural Research, Mexico.

Name and location	Size (ha.)	Altitude (meters)	Med. annual rainfall (mm.)	Temperature (°C.)			Soil types	Principal fields of investigation
				Med. ann.	Abs. max.	Abs. min.		
El Horno, Chapingo, México	153	2,249	768	16.1	34.0	−6.0	Deep, alkaline	Wheat, corn, potatoes, beans; entomology; plant pathology; soils; horticulture; forages
Santa Elena, Toluca, México	50	2,675	792	12.7	26.8	−3.0	Silt clay loam	Wheat, corn, potatoes, legumes; entomology; plant pathology; poultry; soils; etc.
Progreso, Morelos	18	1,950	900	38.0	38.0	−3.0	Clay	Corn, rice, etc.
Zacatepec, Morelos	28	913	750	24.4	44.0	−2.0	Clay loam	Sugar cane, rice; soils; entomology; plant pathology; etc.
CIANO, Cd. Obregón, Sonora	100	70	212	26.5	43.5	−0.1	Leveled silt clay loam	Wheat, rice, oil crops, beans, soya, cotton; soils; entomology; plant pathology
Los Mochis, Sinaloa	160	115	571	25.5	47.5	1.1	Clay loam	Cotton, wheat, corn, oil crops, horticulture; plant pathology; entomology; etc.
Culiacán, Sinaloa	100	53	600	24.4	40.9	3.1	Leveled clay	Wheat, cotton, oil crops; forages; corn; soils; etc.
Mexicali, Baja California	40	1	77	22.3	47.8	7.2	Clay	Wheat; forages; oil crops; corn, sorghum; herbicides; etc.
El Roque, Celaya, Guanajuato	300	1,765	471	18.3	42.4	−8.0	Leveled clay, heavy clays	Wheat, corn, beans; forages; herbicides; soils; entomology; plant pathology
León, Guanajuato	37	1,809	660	18.8	36.5	−2.5	Leveled clay	Potatoes, corn, wheat, etc.

Name and location	Size (ha.)	Altitude (meters)	Med. annual rainfall (mm.)	Temperature (°C.)			Soil types	Principal fields of investigation
				Med. ann.	Abs. max.	Abs. min.		
La Cal Grande, La Piedad, Michoacán	100	1,680	1,034	19.0	36.3	0.0	Heavy clay, leveled	Wheat, barley, corn, beans, etc.
Pabellón, Aguascalientes	46	1,900	560	17.9	36.9	−4.7	Deep clay loam	Corn, vegetables, beans, etc.
Torreón, Coahuila	90	1,120	238	21.7	37.0	−5.0	Deep sandy clay	Cotton, wheat; forages; vegetables; herbicides; entomology; plant pathology
La Campana, Chihuahua	1,156	1,470	300	15.2	39.0	−10.0	Fine clay, sandy loam	Forages, animal nutrition, etc.
Cd. Delicias, Chihuahua	15	1,165	453	17.8	40.5	−11.0	Deep, leveled silt clay loam	Wheat, cotton, corn, sorghum; sesame; soils; entomology; plant pathology; etc.
Río Bravo, Tamaulipas	45	30	419	23.6	46.0	−4.0	Leveled clay	Cotton, corn, wheat, sorghum; soils; entomology
General Terán, Nuevo León	30	332	475	23.0	43.0	−12.0	Alkaline, clay	Citrus
Cotaxtla, Veracruz	147	13	1,623	24.9	41.5	3.0	Clay loam, clays	Rice, corn, forages; beans; entomology; plant pathology; herbicides; poultry
El Palmar, Veracruz	314	180	2,500		42.0	8.0	Silt clay loam	Rubber
Iguala, Guerrero	23	753	1,115	27.1	44.0	7.0	Clays, sandy clays	Corn, sorghum, beans, vegetables; sesame; soils
Rosario Izapa, Chiapas	203	400	3,428	24.2	34.5	15.5	Silt loam	Cacao, sugar cane

Corn

According to official estimates, the 1961 Mexican corn crop is about 10% over that of 1960. The increase is notable principally because it was achieved in spite of serious drought losses that occurred again in 1961, although not exactly in the same areas of the country as in 1960. The northern part of the State of Veracruz and adjacent areas and the Bajío area of west-central Mexico were mainly affected by the lack of rainfall. It is apparent that improved varieties and cultural practices are contributing to the increasing output of grain in spite of the many obstacles.

Nevertheless, the uncertainties of corn production under natural rainfall conditions in Mexico are such that additional measures must be taken to assure greater stability in the supply of this essential cereal to meet the needs of the rapidly growing population. Tremendous losses are incurred every year from insects and storage rots developing in inadequate and improper storage facilities. Surplus corn coming from areas with unusually favorable growing conditions cannot always be carried over to meet shortages that develop later, or efficiently moved into other market areas. A system of planned reserves would seem to be indicated to help smooth out the wide fluctuations in production resulting from the erratic rainfall patterns. Increased acreages of corn grown under irrigation and in the more dependable rainfall areas would be desirable to provide a relatively stable assured minimum of grain. Since additional lands are not available, this would mean adjustments in present cropping systems to obtain greater efficiency in land and water use of that now available.

Prior to 1961 the corn improvement program was concentrated largely at the four regional centers of Cotaxtla, El Roque, CIANO, and El Horno and oriented toward improvement of corn in the large commercial production areas that each represented. With the fusion of the two institutions of agricultural investigation in 1961, consolidation and evaluation of the programs and materials of both was necessary. Yield trials of the recommended corns developed by both institutions were conducted at a great many stations. In addition, an attempt was made to combine the germ plasm collections into a single resource. Original collections made by both organizations were planted out by regions at the center nearest the area of collection. Then similar materials were grouped together to form single "varieties" composed of varying numbers of original collections. Some such procedure is essential to reduce the number of "varieties" and make it possible to handle the many thousands of collections made. The work of consolidation forced delays in several projects, but this was unavoidable under the circumstances. Approximately half the total program is devoted to the formation of open-pollinated varieties and the rest to hybrid development.

COTAXTLA

Under the expanded new Institute the general program in tropical areas continues unchanged, with testing carried on in winter plantings at San Rafael and summer plantings at Cotaxtla, Veracruz. The controlled pollination work is done during both winter and summer cycles at Cotaxtla.

Sizable commercial production of the tropical white dent hybrid H-507 was realized in 1961 and verified experimental results obtained prior to its release in 1960. Requests for permission to produce it have been received from private interests in Mexico and from both private and public interests in Central America.

In preliminary yield trials, earlier maturity hybrids and synthetics as well as those with shorter height have given lower yields than the full-season and taller types. To what extent satisfactory yields can be obtained from earlier and shorter plant types remains problematical. These types are necessary, however, for certain areas and special cropping sequences, and work will continue on their development.

Sporadic outbreaks of the corn stunt virus continue to cause losses in various parts of the tropics. Most serious losses appear to occur when corn is planted shortly before the beginning of the summer rains—either under irrigation or with a first rain that is followed by a couple of weeks of dry weather. Under such conditions the populations of the leafhopper vector are high and the young corn is the most succulent green plant on which to feed. Practically nothing is known of the host plants of the virus except that they must be widespread and exist in great numbers to account for the tremendous virus infections that occur. After a few heavy rains the populations of vectors are greatly reduced, alternate plants to feed on have freshened up, and virus infection in corn drops off to relatively minor proportions.

Conditions for field infection appear ideal in the Culiacán area of Sinaloa when plantings are made in April and May, and essentially 100% infection was obtained in 1961. The area thus offers a good natural laboratory for use in conjunction with the artificial inoculation studies under way at Cotaxtla. Both fairly resistant and very susceptible lines have now been isolated from corns from Cuba, the Dominican Republic, Honduras, and Mexico. Segregations from the intercrosses of these lines are being studied to obtain information on the inheritance of resistance. All corns tested thus far from the United States have been very susceptible to the disease.

On-farm tests of new varieties were continued during 1961. Results indicate that one white dent synthetic formed from ten inbred lines is sufficiently promising to merit further testing and increase for possible distribution. The need for open-pollinated corn varieties in Mexico is likely to remain for the foreseeable future.

In addition to the regular development program of varieties and hybrids, more emphasis is being placed on the formation of composite populations with special characteristics, such as resistance to *Helminthosporium turcicum*, resistance to stunt virus, etc.

These populations will be developed and maintained by recurrent selection procedures to provide readily available germ plasm for use in cases of necessity and to meet future needs.

El Roque (Bajio)

During 1961 a large part of the effort at this center was concentrated on evaluating and comparing the improved varieties, hybrids, and collections of the two previous organizations in order to combine the materials into one program. No new varietal recommendations were made for this area during 1961. The hybrids H-220, H-230, and H-309 continue to be recommended for natural rainfall areas, and H-352 and H-353 for irrigated plantings.

Tests were carried out at Cuidad Guzmán, Pabellón, León, and Antúnez, as well as at El Roque. The variety Cafime (a selection from the race Bolita from Oaxaca) has gained acceptance in parts of the northwestern section of the area where low rainfall is the rule.

Losses from drought were again widespread in this region, a fact emphasizing anew the need for further study of the use of sorghum as a complementary cereal in marginal areas.

Results of the last several planting cycles indicate that a great many other corn germ plasm sources can be incorporated into the breeding program for this important area. The long and relatively temperate growing season provides a wide choice of crops and crop sequences under irrigation. High-yielding corn varieties within a wide range of maturities can be produced for these conditions. An especially promising type of combination is that of tropical corns with high altitude corns. Several excellent populations of this type are under development and undoubtedly will result in higher yields. Both yellow and white populations are now available. Two other sources worked into Mexican corns of this area are collections from Chile and material from the United States. Neither by itself is satisfactory, but when they are combined with native corns and the combinations are selected under conditions of the area, useful characteristics of earliness, yield, ear placement, etc. are contributed. Varieties of different maturities may be needed to allow the development of more efficient crop-succession plans to best utilize the growing season available; at present, however, the primary objective is to obtain high and dependable yields.

Head smut (*Sphacelotheca reiliana*) continues to be a problem of concern in localized areas, especially near Cortazar, Guanajuato. Data collected over several years on dates of planting, selections for resistant lines and varieties, and fungicide treatments lead to several tentative conclusions. Seed treatment, at least with all common fungicides tested, is ineffective. Date of planting is not a certain means of avoiding infection since consecutive years' testing of the same genotypes indicates completely different dates of planting. Present systems of inoculation are not sufficiently dependable to provide consistent, repeatable results for a genetic study of inheritance of resistance. More must be learned about the influences of temperature, moisture, soil aeration, and probably other factors such as soil pH on the infection of seedling corn plants. The fact that the severe infections tend to occur in the same places year after year in spite of the widespread presence of inoculum and susceptible corn varieties, indicates the possibility of local conditions in the soil being of importance.

In addition to the principal effort devoted to securing maximum yields, other special pools of germ plasm are being built up for possible future work on pop corns, sweet corns, and other specialties. The work on incorporation of the drought-resistant character "latente" into varieties for natural rainfall conditions is being continued.

Ciano

Although corn has not expanded rapidly as a major crop in the northwestern irrigated regions of Mexico, it is gradually being accepted as an important part of the diversification of production in the area. In the

Yaqui Valley the commercial plantings are made during late August and early September for harvest in late January or February. As additional demands for irrigation waters develop with intensified use of the land over the previous wheat and cotton system, possible restrictions on acreages may appear because of limitations of water supply.

The white hybrids H-503 and H-507 continue to be recommended for fall plantings. The early white dent hybrid H-412, released in 1960 for spring production in the Yaqui Valley, has spread south into the States of Sinaloa and Nayarit with excellent results. One-year trials in the Matamoros area of northeastern Mexico indicate that it can be advantageously used there also. Meanwhile, a program to combine slightly earlier lines from the northeastern area with the two best lines entering into the formation of H-412 has been started, and a hybrid recommended especially for the Matamoros area should be available in a relatively short time. Since substantial corn and sorghum increases are being made in this area with the shift away from cotton, a good corn hybrid would be highly desirable. Currently, hybrids from Texas are grown to some extent, but the yields obtained indicate that better corns must be produced by a breeding program aimed directly at this area.

Spring (March) corn plantings in the Yaqui Valley have not become commercially important since there is land and labor competition with cotton planting and wheat harvest at present. In the event of changes in the cropping pattern, the hybrid H-412 represents an attractive alternative for spring planting, with a three-year average yield of well over 4 ton/ha. in experimental plantings. Meanwhile, the possibility of planting corn on the land immediately after the wheat harvest should be explored from the standpoint of desirability in the cropping sequence. Date-of-planting trials have been resumed with plantings made every 15 days during the entire year to obtain more precise data on the most favorable dates for planting. In addition, a special effort is being started to select corns resistant to summer heat and with a long growing cycle that could be planted in late June or July and that would flower and form grain in the cooler weather of September and October.

EL HORNO

Within the area referred to as the high central plateau and the high valleys are a great many abrupt topographical features that result in precipitous changes in rainfall, soils, and temperature and an almost infinite number of micro-climates. No improvement program can possibly develop improved varieties for all these areas, and must confine itself to the major divisions of the area.

High-yielding hybrids for the irrigated and better rainfall areas of the high central plateau and principal valleys have been in commercial production for several years. This breeding program is farther along in several of its phases than that in any other part of Mexico. The substations of Santa Elena, at a higher elevation and with more rain than El Horno, and El Mexe, at a lower elevation and with less rain, have each contributed improved varieties and hybrids appropriate for more specific local conditions. An additional corollary program begun three years ago in the State of Tlaxcala has now achieved advances in varietal recommendations for that specific area.

Several new combinations appear to offer substantial promise for the drier, temporal (natural rainfall) conditions of the high central parts of Mexico. Perhaps the most important of these is the character "latente" (see 1960-1961 report). Nevertheless, large sectors of the natural rainfall area are strictly marginal for corn production and probably should not be used for corn; for some of these, new sorghum selections appear as useful alternatives. A substantial percentage of the region should be removed from cultivation because of steep slopes or dry conditions or both, and returned to grassland or reforested. Funds used for corn improvement in such areas would be largely wasted at this time.

Another factor to be considered is this region's proximity to the large population center of Mexico City. Land values rise above their agricultural values for general field crops. In the Valley of Mexico, a good part of the hybrid corn seed is used to grow silage to feed to dairy cows. More intensive use is being made of favorable sites to produce lettuce, carrots, and many other vegetable and fresh food crops for local markets. Such developments may be expected to continue and increase.

Along with the development of the animal feeding industry has come a demand for yellow corns. Provisional varieties and hybrids are now ready for commercial-scale testing from the program at El Horno. In addition, yellow corns have been developed and are ready for production at each of the other major centers. Since the big demand is for white corn to be used directly as human food, there is some question as to the desirability of attempting to produce large quantities of yellow corn at the expense of white corn production. Substantial gains must be made in total corn production before diversion to animal feeding can be accomplished. Sorghum grain appears to be an ideal complement, at least for the near future.

SEED PRODUCTION

Reviewing the over-all situation of corn as a crop in Mexico, one is struck with the importance of the grain as a human food. Centuries of dependence upon it as the principal food have established it firmly in customs and preferences and forced its production in areas distinctly limited in moisture, soils, and fertility. Vast areas of the country have been depleted of their native fertility through continued corn culture and are too dry for the practical use of much commercial fertilizer. Little can be done in much of this area to raise the disappointingly low yields, but the people raise corn year after year to survive.

In the areas of better soils and rainfall and under irrigated production, advances have

Date-of-planting trials and selection for heat resistance are aimed at more flexible crop sequences in Sonora.

come through better varieties, fertilizers, and cultural practices. In analyzing why still greater advances have not been made, one quickly finds that at least one reason is that farmers are not actually planting seed of the recommended hybrids in many cases. To some extent this may be due to the need for more effective extension work, but in good part it is also due to deficiencies in the quality and quantity of the seed produced and distributed to the farmers. Perhaps a general re-evaluation of the over-all breeding program is needed to study the possibility of shifting still more in the direction of open-pollinated variety development in order that seed may pass from farmer to farmer. Efforts might then be concentrated on hybrids only in the larger and more uniform areas so that quality could be maintained and true hybrid seed planted in those areas. In any case a great deal remains to be done just to get varieties already developed into large-scale production on the farms through the availability of good seed to the farmer.

Collections from Ethiopia being increased for testing in Mexico.

Sorghum

Sorghum continues to gain gradual acceptance as a major cereal crop in Mexico. Its natural characteristics of tolerance to heat and drought make it a logical crop with which to supplement and extend the supply of the basic cereal corn. Thus far, its principal use has been as feed in poultry and hog production.

Commercial grain production is centered in three principal areas: Sinaloa on the west coast, the Bajío of west-central Mexico, and around Matamoros in the Río Grande Valley on the Texas border. Production in the Matamoros area increased sharply in 1961 to an estimated 150,000 tons, practically double the 1960 production. Total production of the country in 1961 is estimated officially at 225,400 tons from 122,500 hectares as compared with 209,000 tons from 116,000 hectares in 1960. There are other private estimates placing both the acreage and production considerably higher. Interest is increasing both in grain and in forage sorghums in many other areas scattered throughout the country outside the main areas of commercial production. According to the official figures the average yield of grain sorghum in Mexico is double that of corn per acre. This comparison is of interest but perhaps not truly indicative of the yielding capacity of the two crops since sorghum is still a relatively new crop and grown on a much smaller acreage.

Breeding work is centered at El Roque near Celaya, with varietal testing carried on also at CIANO, Culiacán, Matamoros, and El Horno. Work at El Horno includes only a few materials from the main breeding program as testers and is concentrated on isolating germ plasm suitable for the high plateau area of Mexico.

For the most part, improved varieties from the various public and private breeding programs of the United States have been utilized in arriving at recommendations for the various production areas in Mexico. Generally this has proven to be the quickest and most efficient means of establishing a recommended variety. Sorghums are much less specific in their response to environment than are corn varieties, and a single hybrid or variety may do well under quite different conditions, as shown by the performance in Mexico of U.S. developed hybrids. Eventually hybrids developed in Mexico will probably to a large extent replace those introduced.

For the extensive area adjacent to Texas, the hybrids from Texas are well suited. Likewise the Texas hybrids (from both public and private sources) do well in the Yaqui Valley of Sonora. Data from Sinaloa are only preliminary, but seem to indicate a similar situation. The Bajío area of 1,600 to 1,800 m. elevation is about the practical limit at which U.S. varieties can be recommended. At these elevations the hybrids begin to show little advantage over open-pollinated varieties as the limiting factor becomes the cooler temperatures of the area. Varietal selections Redbine 2 and Kafir 60 have been continued as recommended varieties in the area, along with Texas hybrids 620 and 660.

At elevations above the level of the Bajío no germ plasm from U.S. selections has been dependable for producing grain. Additional collections from high elevations of Africa have been and are being introduced in the attempt to develop suitable varieties for the higher and cooler plateaus of the country. Three promising selections made at El Horno in 1959 and 1960 from such introductions were widely tested during 1961. These three are suitable for both grain and forage production and are now being put into small-scale commercial production at elevations of 2,000 m. and above.

Crosses of these three selections and other similar types have been made to genetic stocks carrying the known factors for earliness in an attempt to combine earliness and the ability to set seed at low temperatures. Additional populations of this type are being developed in order to make selections suitable for the particular conditions in the potential areas of production in the high altitudes.

Development of hybrids formed under Mexican conditions also continues, with main emphasis on the Bajío area. Several experimental hybrids including red, white, and yellow grain colors were selected in 1961 for further testing. None will be released until adequate data prove superiority over varieties now available, although several appear very promising.

FORAGE SORGHUMS

As the need for livestock feed increases, more and more interest is developing in sorghums. The perennial type Almum has been well accepted, as has the annual variety Honey. Varietal recommendations have not been strongly pushed for two reasons: available moisture and factors other than variety have been limiting in most areas, and dependable sources of quality seeds are not developing as rapidly as appears indicated. Yields of silage from sorghum have been generally about the same as silage from corn, but sorghum has the advantage that where moisture is available under the longer seasons more than one cutting may be made from the same planting.

Production of forage-type sorghum seed is relatively difficult and few growers are interested at present. The situation is being overcome to some degree, however, by individual growers saving seed blocks for their own use and by the entry of private seed companies into production on a small scale. Substantial increases are likely in forage sorghum production.

EXPANSION

Widespread observational plantings of a selected series of grain and forage sorghums are being continued. Results of this are showing up in increased sorghum plantings in areas where sorghum was not previously grown. One such series of 25 locations in northern Jalisco during 1961 led to the conclusion that sorghum is more productive of both grain and forage than is corn in that area. This again points to the potential of sorghum in supplementing corn in areas of poor and badly distributed rainfall.

The Matamoros area is producing more sorghum and more corn to add diversification to the traditional cotton-cropping pattern. A few growers are increasing production of grain sorghum because of its ease of handling under completely mechanized operation. Acreage of corn is likely to increase sharply in this area and acreages of sorghum probably will fluctuate widely while adjustments are made away from cotton.

When sorghum is grown under reasonably good cultural conditions, only relatively minor difficulties have been encountered with disease and insect pests in Mexico. Perhaps this is due in large part to the dry growing conditions. The humid tropical areas have not yet accepted either grain or forage sorghums to any extent, among other reasons because head rots in the grain types and leaf diseases of the forage types are severe during the rainy season. Drying of the grain is more difficult under humid conditions than is the case with corn. However, a substantial potential exists for planting sorghums near the end of the rainy season in the tropics so as to harvest them during the dry season. An additional crop could thus be produced on residual soil moisture which is not now being fully utilized.

A very important aspect concerning expansion of sorghum production remains to be resolved: the lack of a dependable market. In general, sorghum grain is still underpriced as compared with corn. Relatively small changes in the total supply contribute to wide price fluctuations, whereas corn prices are supported through government channels. The uncertainties of price and the lack of widely available marketing channels thus discourage many farmers from producing sorghum grain. A further unsolved problem is that of bird damage, which in certain areas is enormous when migrations of birds coincide with ripening of the grain.

In spite of the problems and uncertainties, interest in sorghum production is increasing in Mexico. The crop's inherent characteristics of resistance to heat and drought and the ease of mechanization of production tend to assure its continued expansion. At present it lends itself at the one extreme to the very small producer who plants by hand and harvests the ripe heads with a machete, and at the other to a grower in the Yaqui Valley with over 400 hectares completely mechanized (1961 average yield 125 bu./A.) who markets his entire crop through his poultry broilers and eggs.

Technicians observing dwarf durum wheat lines.

Wheat

Judging from results observed so far during the current wheat harvest, a new record yield per unit of planted area will again be achieved.

During ten consecutive years, it has been possible to increase the national average yield per hectare. In terms of national production and the area devoted to the wheat crop, the national average unit has risen by approximately 100 kg./ha. each year—from 900 kg./ha. in 1952 to 1,900 kg./ha. in 1962.

During the present harvest, yields above 4,000 kg./ha. have frequently been observed, and in several important producing regions average yields reach 3 ton/ha. Moreover, it is now difficult to find progressive farmers who obtain harvests below 2 ton/ha.

Northwest Region

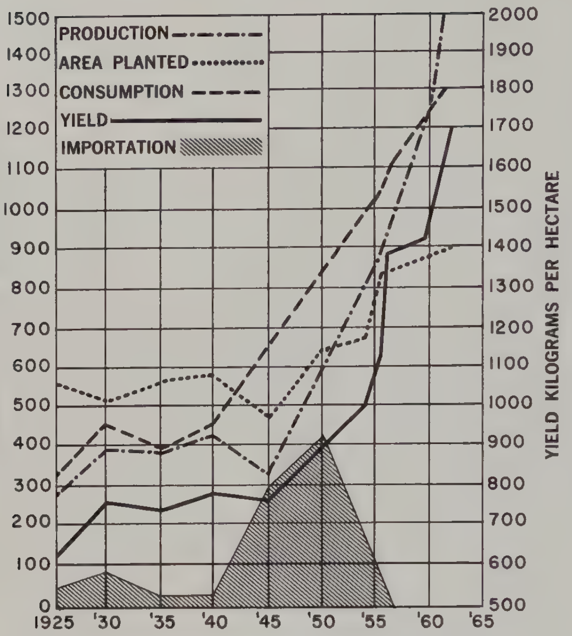
REGIONAL PRODUCTION

Although the harvest of the commercial crop is not yet completed, indications are that the total production in this region will surpass that of last year, which was the highest on record. Yields per unit of area will also break all previous records.

The current season was characterized by climatic conditions very favorable for the development of the wheat crop, with the exception of the coast of Hermosillo, where considerable frost damage occurred during the middle part of March when much of the wheat was flowering, or when the grain was beginning to form. Consequently, in the Hermosillo area yields are variable and many farmers have suffered severe losses, whereas others are harvesting good crops. Although these losses will affect the region's over-all production, they will probably be more than offset by the record-breaking yields in Sinaloa and in the Mayo Valley and Yaqui Valley in Sonora.

In general, the grain from this year's crop has high test weight, with most varieties producing test weights of 78 kg./hl. and above; many samples of Lerma Rojo reached 82 kg./hl.

There was considerably less lodging during the current crop season than in the previous two years, largely because of a shift to vari-



Wheat production, importation, consumption, yield, and area planted—Mexico, 1925–1962.

eties with greater resistance to lodging—Nainari 60, Pitic 62, and Penjamo 62. These newer, lodging-resistant varieties contributed greatly to the production in the southern part of Sonora and in Sinaloa.

Climatic conditions were again favorable to the development of "black point," but this discoloration in commercial grain was of very little importance in production, and the over-all grain quality of this harvest is very good.

Diseases and Pests

All the principal commercial varieties remained essentially free of stem-rust infection, and this disease had no effect on yield. Leaf rust, as always, was prevalent throughout the region and was moderately severe on Lerma Rojo and Yaqui 54; although it probably contributed to the lower yields shown by these two varieties, the adverse effect of lodging was far more important. Leaf rust occurred on all of the newer varieties, Pitic 62, Penjamo 62, and Nainari 60, but only in trace to light infections. Nainari 60 is more resistant to leaf rust than any of the other commercial varieties.

The English grain aphid, *Macrosiphum granarium*, was present throughout the region, but the population of this insect did not build up to destructive proportions.

Varietal Performance

For the past three years, Lerma Rojo has been grown on from 65% to 85% of the commercial acreage in the States of Sonora and Sinaloa. This year, however, the area cultivated to Lerma Rojo was less than that seeded to Nainari 60. In the Yaqui Valley it is estimated that more than 45% of the area was seeded to Nainari and 35% to Lerma Rojo. Pitic 62 and Penjamo 62 constituted together more than 18%, and the remainder was made up of a large number of relatively unimportant varieties like Gabo 56, Huamantla Rojo, Yaqui 54, Constitución, etc.

The outstanding performance of Nainari 60, Pitic 62, and Penjamo 62 contributed greatly to the region's increased yields. All three are resistant to lodging and even under heavy fertilization no lodging occurred, whereas under the same conditions in adjacent fields Lerma Rojo was completely lodged. In terms of the yield of Nainari 60 (100%), Lerma Rojo yielded 89%, Yaqui 54 74%, and Pitic 62 and Penjamo 62 113% and 114%, respectively.

NEW VARIETIES FOR 1962-1963

Seven new varieties were selected for increase on the basis of their performance during the past two years. All seven carry genes for dwarfness which makes them relatively resistant to lodging, the principal factor limiting production on the West Coast for the past two years. In addition, all seven varieties will generally yield as much as or more than Pitic 62 and Penjamo 62.

Three of the new varieties—Lerma Rojo 64, Lerma Rojo 64A, and Penjamo Tardío (provisional name)—are soft wheats with milling and baking characteristics similar to those of Lerma Rojo, the standard variety for the past ten years.

The other four—Mayo 64, Sonora 63, Sonora 64, and Sonora 64A—are wheats with grain of hard texture, red in color, with excellent milling characteristics, medium-strong to strong dough properties, and good baking characteristics. In many respects these varieties are similar to Yaqui 54 in quality characteristics; Mayo 64 and Sonora 64 will probably prove superior to Yaqui 54 in quality.

Sonora 64 and Sonora 64A have two genes for dwarfness and are from 15 to 20 cm. shorter than the other new varieties and also Pitic 62 and Penjamo 62. This additional dwarfing will permit even heavier applications of fertilizer and more optimum irrigation practices without danger from lodging, and should result in even higher yields from these two varieties under commercial conditions than have been obtained in experimental plots, where they have not been grown at optimum fertility levels.

Mayo 64, Lerma Rojo 64, Lerma Rojo 64A, and Sonora 63, are all of the same maturity class as Penjamo 62, and approximately two to three days earlier than Pitic 62. Penjamo Tardío, on the other hand, is 18 to 20 days later than Pitic. Sonora 64 and Sonora 64A are very early maturing, and are approximately ten days earlier than Penjamo 62. All seven new varieties surpass Pitic 62 in grain test weight.

It is believed that the cultivation of these new varieties on a large commercial acreage will result in an additional important increase in the yield of grain per hectare in the Northwest, as well as in the production of large quantities of grain with strong gluten and good dough properties—qualities that are urgently needed by the industry.

NEW EXPERIMENTAL LINES

During the current season, several lines were found which in preliminary yield tests indicated superiority over the seven new varieties being increased.

The highest yielding line in the entire nursery was from the cross [(Frontana × Kenya 58–Newthatch) N10-B] × Gabo 56, II 8156-1M-2R-4M. Its average yield in three replicated yield trials was 6,371 kg./ha., or 115% of the yield of Pitic 62. Unfortunately, the grain of this line was found to be segregating for color, and will need to be reselected before it can be multiplied for commercial release.

EARLY GENERATION MATERIALS

Two and a half years ago the wheat breeding program was reoriented to give more emphasis to the following points:

(1) early generation testing for quality characteristics (F_2, F_3, F_4) in order to increase the proportion of good-quality wheats entering the yield testing stage;

(2) conversion of the entire program to dwarf straw types;

(3) incorporation of the leaf-rust resistance from the Sears Aegylops translocation into commercial Mexican varieties.

It will require several years before all these considerations will produce the desired varieties, but already progress is visible.

Quality Aspects

Since early generation Micro-Pelshenke, mixogram, and sedimentation tests were initiated, the proportion of lines with strong gluten properties entering the F_5 generation has increased manyfold.

Breeding for Leaf-rust Resistance

Several years ago, a program was initiated to incorporate the immunity obtained by Dr. Sears from a translocation of *Aegylops umbellulata* to Chinese wheat. This attempt was made in two ways: (1) by crossing directly the translocation line developed by Dr. Sears into Mexican commercial varieties and subsequently backcrossing to the commercial varieties; and (2) by employing two lines developed by Dr. Knott of the Canada Department of Agriculture in which he had incorporated the Aegylops resistance into a Thatcher background. The original work with both of these parent lines was made with commercial varieties possessing tall straw (Lerma Rojo, Nainari, Yaqui 54, etc.) with the thought that once the leaf-rust immunity was incorporated into tall-strawed Mexican varieties by backcrossing, the line could be easily converted to dwarf varieties.

Both these approaches encountered unforeseen delays, since virtually all the lines obtained from these original crosses possessed straw that was extremely tall and weak and, therefore, susceptible to lodging. Moreover, almost without exception, the lines were of extreme late maturity.

Two years ago, crosses were made carrying the Chinese Aegylops resistance directly into Mexican dwarf lines. During the current season, F_4 lines were found which were homozygous for their immunity to leaf rust. Lines with one, two, or three genes for dwarfness were found combined with early maturity. Using these early maturing, dwarf, leaf-rust immune lines as parents, it will be very easy to transfer the leaf-rust immunity to commercial dwarf wheats with good milling and baking characteristics and high yields.

Dwarf Durum Wheats

During the past year, considerable progress was made in the program designed to produce a dwarf durum wheat variety with high yield and good quality for spaghetti production. It is now evident that within the next year varieties will be developed which will combine these characteristics. Many of the F_3 and F_4 lines from a number of different crosses showed outstanding promise during the current season. A few varieties derived from the first backcross were placed in preliminary yield trials and outyielded all other commercial durum varieties during the past season. The most promising lines, however, are in the F_3 and F_4 of the second, third, and fourth backcrosses to the Mexican durum variety Tehuacán.

Bajio

REGIONAL PRODUCTION

Climatic conditions in this region were generally favorable for the establishment and development of the wheat crop. Rather high temperatures, however, occurred during February, and because these coincided with the rationing of irrigation water the normal development of the wheat plants was partially affected. Owing to the reduced volume of water available for irrigation, the national irrigation commission was forced to reduce the area of wheat which should have been planted under irrigation.

Had it not been for these two factors, the Bajío region, like the Northwest, would have been able to reach a new record in production and yields.

For the first time in the last five years, the attack of the English grain aphid, *Macrosiphum granarium*, did not represent a significant factor in the reduction of yields.

Varietal Performance

Even though there was sufficient quantity of seed of new varieties, such as Huamantla Rojo, Penjamo 62, and Pitic 62, which would have served to increase yields in the Bajío, the distribution of this seed was not as widespread as in the Northwest.

Lerma Rojo constituted from 75% to 85% of the area planted in this region. The varieties Chapingo 52, Chapingo 53, Gabo 56A, and Barrigón have practically disappeared from cultivation. Huamantla Rojo was probably the second most important variety, representing approximately 15% of the total wheat planted. The remaining lines included Nainari 60, Pitic 62, and Penjamo 62.

The outstanding performance of Penjamo 62, Pitic 62, and Huamantla Rojo contributed greatly to increasing yields. Huamantla Rojo and Pitic 62 yielded 5% more than Lerma Rojo and Nainari 60, 17% more. Penjamo 62 showed the best performance with a yield over 30% above that of Lerma Rojo.

NEW VARIETIES FOR 1962-1963

Of the seven varieties selected for the Northwest region, four appear promising for the Bajío: Mayo 64, Lerma Rojo 64A, Sonora 63, and Penjamo Tardío. Generally these varieties are, in one way or another, superior to Penjamo 62 and Pitic 62.

The good effect that these varieties are expected to have on wheat production in northwestern Mexico may also favor wheat production in the Bajío, where the need of wheat with better milling and baking characteristics is even more urgent.

The variety provisionally called Penjamo Tardío is very similar in quality to Lerma Rojo and Huamantla Rojo; however, its somewhat longer vegetative cycle will make it very valuable for use at the beginning of the planting season, not only in the Bajío but also in other areas where a late maturity wheat is needed.

NEW EXPERIMENTAL LINES

From the experimental material planted it was seen that without exception the dwarf wheats outyielded all other commercial varieties included in commercial experiments.

It is evident that a possibility exists of multiplying and distributing the dwarf varieties which show marked superiority to Lerma Rojo. It should be relatively easy to increase current yields by more than 30%, assuming that Lerma Rojo continues to occupy nearly 75% of the total wheat acreage.

Study of New Wheat Areas

The increasing demand for bread in Mexico may soon reach higher levels than those obtained in the total production of this cereal. Statistics indicate that an additional 70,000 to 80,000 tons of wheat are needed each year in order to meet domestic consumers' demands. Potentially the new varieties are superior to those being grown on the acreage presently under cultivation (800,000 hectares), and it should be possible to produce approximately 2,400,000 tons annually within the next ten years, if yields reach a level of 3,000 kg./ha. Nevertheless, the program has initiated a study of the adaptability and cultivation of wheat in areas where this cereal has not previously been sown.

Experimental plantings have been established in northwestern Chihuahua in order to develop early, high-quality varieties for summer and rainfall plantings in that area, and in northern Tamaulipas to develop late, high-quality, disease-resistant wheats for winter irrigated plantings there.

On the basis of highly satisfactory data obtained this summer, approximately 5,000 hectares have been planted in northwestern Chihuaha and 2,000 hectares in the northeastern part of the same state.

Oats

At present oats are planted in Mexico on approximately 90,500 hectares, and the average yield is no higher than 700 kg./ha. It is estimated that 95% of this area is planted to the variety Burt, which was introduced into Mexico from Kansas some 42 years ago for use by a group of Mennonites who settled in northwestern Chihuahua.

Burt now shows susceptibility to stem rust (*Puccinia graminis* var. *avenae*) and because of this it may have to be discarded in the near future. Since in addition, the oat industry requires varieties of better quality, the oat program is currently looking for varieties possessing good agronomic and industrial characteristics.

As a first step toward solving the problems of low yields and lack of adapted varieties, many oat introductions have been made, mainly from the United States. Several of these introductions are superior to the oat varieties usually planted in Mexico. They will be released to the farmers this year.

Of the oat varieties introduced from the United States, the following have shown promise and good quality:

Name	*C.I. No.*
[(Bond-Rainbow × H-J) Landhafer] Andrew[3]	7399
Alamo [(Mindo × H-J) Landhafer]236-53-151	7359
Tane (Victoria × H. Banner) 119-50-8	6994
AB-177	—
Nodaway	—

The quality of these oats has been tested in the laboratory of the Quaker Oats Company at Cedar Rapids, Iowa, where a sample of the variety CI-7399 was rated the best ever analyzed there. It should thus be possible to release to farmers in the near future better oats than those they are planting.

A crossing program has been initiated in order to combine the good characteristics observed in some of the oats studied, such as earliness, short, stiff straw, high yield, and good quality.

Malting barley is a very promising crop for the Bajío.

Barley

Barley has been cultivated in Mexico for many years, but the breeding program for this crop was initiated only in 1957.

Although the program is thus relatively new, some very promising results have been obtained. For one thing, the average yield in Mexico, which was formerly only 750 kg./ha. has now reached three times that amount, or approximately 2,400 kg./ha. This has been made possible by partly replacing the native mixed varieties with two improved varieties, Toluca I and Vantage, which were released to farmers in the summer of 1958. Credit for the increase in yield should also be given, at least in part, to the employment of better cultural methods by the farmers.

Although Toluca I and Vantage have contributed to increasing yields, both varieties are deficient as regards either agronomic characteristics or quality. Toluca I is a tall variety, susceptible to shattering but with good quality, whereas Vantage is short and resistant to shattering but possesses poorer malting quality and is later than Toluca I.

Barley could represent an increasingly important cash crop for the farmers in Mexico, since there is a rising demand for barley grain on the part of the malting industry. In general, barley is more economical to grow than wheat, but because it requires much more attention at time of harvesting in order to avoid losses due to shattering, many farmers prefer to plant wheat.

EXPERIMENTAL RESULTS

At the CIANO station, Sonora, a heavy infection of yellow dwarf virus occurred in a large number of lines from the United States which were planted in the winter of 1961-1962. Fortunately, almost all the lines and varieties used in the breeding program showed good resistance.

Many lines included in yield trials at CIANO and in the Bajío in 1961-1962 gave better yields than Toluca I and Vantage, which were used as checks. Several of these lines yielded from 20% to 60% more than either Toluca I or Vantage.

Unfortunately, it has not been possible to test the malting quality of most of these lines. However, of 25 lines analyzed, the following are suitable for malting:

Name	*Pedigree*
Feebar × Kindred	RF-623
Val. × Og.	II-722-4b-2t-1t-(1-176)
Og.-CI-3734 × Ba.	II-1511-4b-1t-4b-1t
(Fr.16 × D.c.1-Un) Fun.-Tch.929	II-1542-2t-2b-1M
Og.-Fr.109 × Tch.929	II-1501-4t-1b

Of these lines (Fr.16 × D.c.1.-Un) Fun.-Tch.929 is the best from an agronomic point of view and will be increased in the summer of 1962 for release to farmers.

Because of the range of conditions under which barley is grown in Mexico it is necessary to develop varieties of two types: one suited to winter planting under irrigation, with short straw and resistance to lodging and shattering; the other suited to summer planting under rainfall conditions and possessing less resistance to lodging and shattering. Many crosses have been made in order to obtain a combination of these characteristics, and from the considerable number of advanced lines now available it will be possible to develop a good variety.

An important aspect of the breeding program is the establishment of a barley laboratory for quality testing of individual plants of generations as early as F_2 or F_3. This laboratory will be set up in the summer of 1962, and will assist in a better selection of hybrids as regards quality, as well as save work and expenditure in handling of segregating lines.

Farmers harvesting their bean crop in the high plateau of Mexico.

Beans and Soybeans

The experimental work during the past year continued to emphasize the improvement of beans and soybeans. To increase production of these legume plants, studies were conducted on genetic improvement, diseases, and cultural practices.

Bean Breeding and Improvement

BEAN DISEASES

In 1961, research on the pathology of the bean was mainly concerned with the identification of races of bean rust and the study of inoculation methods for *Rhizoctonia solani*, the root-rot causal organism. This is not to indicate that work on the race complex of bean anthracnose is being discontinued, but as of last year more attention was placed on rusts and root rots.

Bean Rust

In Mexico, bean rust (*Uromyces appendiculatus*) and anthracnose continue to be two important diseases of beans. In some areas, however, rust is becoming the limiting factor in production, especially where the U.S. Pinto bean varieties are used.

To evaluate the importance of these diseases and to determine the frequency and distribution of races, greenhouse studies were planned and conducted. In past years, preliminary results have shown the presence of 16 physiologic races of bean rust distributed throughout the main bean-growing areas of Mexico. In last year's experiments, 15 additional new races were identified. The inoculation of commercial varieties with the identified races showed that the bean variety Canario 101 is susceptible to some of them. Its susceptibility to these races has caused the bean breeders to look for other sources of resistance in the Mexican bean germ plasm and to determine the reaction of the advanced hybrid lines to the new races.

Root-Rot Organisms

Root rots of beans present a serious problem in the northern part of Mexico. During the past few years, a great amount of damping-off has been observed in commercial as well as experimental plots in that region. In order to study, under greenhouse conditions, the effectiveness of fungicides and the reaction of breeding lines and commercial varieties to *Rhizoctonia solani* (the main organism involved in the root-rot complex), it was imperative to first establish the best methods for soil inoculation. With the four methods of inoculation studied, the best results were obtained when the soil was infested with mycelium of the fungus and watered and after three days the bean seed was planted.

The use of fungicides on beans is not a very common practice in Mexico, but many questions have arisen with regard to their effectiveness. A greenhouse experiment was conducted with ten fungicidal substances using a randomized block design. The reading of symptoms on bean plants (based on the size and number of lesions along the hypocotyl) was made three weeks after planting. The results of this trial are presented in Table 1.

TABLE 1.

Effect of seed treatments on emergence of beans planted in soil inoculated with *Rhizoctonia solani*.

Treatment	Rate/ kg. seed[a]	Application method	Av. seed germination[b]
Granosan	1.50 g.	dust	10.7
Check (uninoc.)	—	—	10.7
N.I. Granosan	1.50 g.	dust	10.5
Rhizoctol	1.50 g.	dust	10.5
Phygon	1.85 g.	dust	10.0
Arasan S.F.	1.25 g.	dust	9.7
Delsan A.D.	1.85 g.	slurry	9.5
Tillantina	2.00 g.	dust	9.5
Pureseed	1.00 g.	dust	9.5
Dow 9B	1.50 g.	dust	8.0
Check (inoc.)	—	—	2.2
Morven	1.20 cc.	slurry	1.2
	L.S.D. .05		3.02
	L.S.D. .01		4.07

[a] Dosage commercially recommended.
[b] Calculated on the basis of 11 plants.

Rust is a serious disease of beans along the west coast of Mexico.

The statistical analysis of these results (seed and soil treatments) indicates that all substances tested, except Morven, were able to protect the seed from *Rhizoctonia solani*. The protection provided by Arasan S.F., Rhizoctol, and Granosan, however, lasted longer than that of the other substances.

Races of Anthracnose

To date, 20 races of anthracnose have been identified in Mexico, six of them in the studies conducted in 1961. The races more widely distributed seem to be the MA2 and MA12, and the more virulent continue to be the MA7 and Beta.

GENETIC IMPROVEMENT

The improvement program has now been expanded to include all of the main bean-growing areas of Mexico. In several of these areas, research on beans was carried out for the first time this year, and it was therefore necessary to conduct improvement projects and study farm practices simultaneously. Four uniform trials were conducted at each of five experiment stations; these projects are as follows:

(1) Yield trials comparing the local and the improved varieties.

(2) Observation plots with early generations (F_1, F_2) of crosses made at El Horno.

(3) Evaluation at each new station of a large number of advanced hybrid lines that have been studied in yield trials for several

years at El Horno and Cotaxtla and selected for their agronomic characteristics and resistance to disease. Performance of these lines will be studied and should one of them be adapted, it will then be ready for multiplication.

(4) Planting of 2,000 original collections in order to select from the promising material in each area and to continuously renew the bean germ plasm now stored at El Horno.

Preliminary information obtained from these projects is now available. On the semitropical west coast of Mexico (State of Nayarit) promising individual plant selections were made with resistance to rust, a disease of serious concern in this state. At the Río Bravo station (Tamaulipas), in the northern part of the country, some collections showed tolerance to rust and root rots. These selections are now planted in observation plots in order to evaluate their importance further.

At the Río Bravo station, rust and root rots are a serious problem when the Pinto beans are planted. There is, however, one local Pinto bean variety with small seed which has some resistance to these diseases. Since this variety is well adapted and also preferred in the market, a series of crosses is being made in the greenhouse, using it and the Pinto U.I. III as parents. The progeny will be planted on infested soil under field and greenhouse conditions in order to select for tolerance to root rots and for a seed resembling the Pinto bean III in size and color.

FARMING PRACTICES

The results of experiments at Cotaxtla indicate that mixtures of herbicides are promising for the control of annual weeds in bean plantings (see Herbicides).

Experimental data on bean yields in herbicidal trials are being accumulated. Evidence now at hand shows also that DNBP applied in bands of 30 cm. on the rows plus one cultivation should be recommended. This is the most economical chemical herbicide method, although its effectiveness varies according to the environmental conditions prevailing after the applications.

Experiments on planting dates, planting rates, and use of fertilizers were conducted at the El Horno and Río Bravo stations as well as at Ciudad Guzmán, Jalisco; El Roque, Guanajuato; Francisco I. Madero, Durango; and Santiago Ixcuintla, Nayarit.

PRODUCTION OF BASIC SEED

In order to supply, as determined by law, basic seed of beans to the National Seed Production Agency, the commercial varieties to be recommended throughout the country were planted in isolated plots at El Horno.

According to their adaptation, preference in the market, and agronomic performance, the following varieties will be recommended:

Bayo 158, Canario 101, Mecentral, Canocel, Bayomex, Amarillo 154, Negro 150, and Bayo 164 for the Mesa Central (States of México, Puebla, Hidalgo, and Tlaxcala).

Canario 101, Bayomex, and Bayo 164 for the Bajío (States of Guanajuato, Querétaro, and Michoacán).

Bayo 664, Durango 225, Pinto 133, Bayomex, and Canocel for the North Zone (States of Durango, Zacatecas, and Chihuahua).

Canario 101, Tabasco 5-2, and Bayomex for the Pacific Coast (States of Nayarit, Sinaloa, and Sonora).

Jamapa, Actopan, and Antigua for the Tropical Zone (States of Tabasco, Veracruz, Chiapas, and Oaxaca).

SOYBEAN BREEDING

The soybean crop is growing in importance in other areas of Mexico in addition to the Northwest. To date, the soybean demand is almost exclusively limited to industrial purposes and animal feed production. In many sectors, however, there is a great interest in its possible use for crop rotation, forage production, and human consumption.

In 1961, 8,363 hectares were planted to soybeans in the Yaqui Valley, Sonora, with a production of 11,655,788 kg. which brought an income for the region of 16,318,103.20 pesos. All commercial plantings were made with the variety Lee, which can only be planted from April 15 to May 15; seeded earlier or later, the plants do not grow well, pods develop near the ground, and shattering is heavy at maturity. Since in the Yaqui Valley the soybean crop is normally planted after wheat harvest—which usually extends through May—Lee is not readily acceptable to farmers. Two varieties, Hood and Hill, have proved to be adapted to a later planting date. These two varieties have been in yield trials and observation plots for the past three years with outstanding performance, and will be released for commercial plantings in 1962.

From adaptability tests carried out in other parts of Mexico, preliminary information is available in regard to yield, planting dates, planting rates, adaptation, and seed inoculations. The results of these trials show that in the Bajío the best planting date is during the month of May, at the rate of 70 kg./ha., and the promising varieties are Dorman, Jackson, Hood, Clark, and Hill. In Jalisco, the best plantings were made in June under "temporal" conditions and the best varieties and lines were Clark, Dorman, Jackson, Bienville, N-44-92, F48-3734, Missoy, TI-200-451, D-426-786, D-51-714, D-540-1, and D-50-1674. At Torreón, Coahuila, and Delicias, Chihuahua, center of a cotton-growing area, N-44-92, Clark, and Lee and the lines D-49-286, D-423-132, D-424-786, D-517-14, and N-44-937 proved to be well adapted.

SEED INOCULATION

The effectiveness of several cultures of *Rhizobium japonicum* now commercially used to inoculate the seed of soybean has been questioned, stirring up a heated controversy. Thus far the most effective inoculant in the northwest of Mexico has been Nitragin SW, imported from the United States. Since there are other cultures in the market, this department was asked to determine which inoculants should be recommended. Experiments conducted previously had given inconclusive results.

In 1961, the products, Nitragin and Nitrobacter were compared in trials conducted at El Horno, CIANO, Torreón, Ciudad Guzmán, and El Roque. The results showed that Nitragin SW continues to be the best inoculant for soybean. At all five experiment stations Nitragin-inoculated plants had a heavily nodulated root system. This was not the case with Nitrobacter.

Breeding potatoes in the greenhouse at El Horno.

Potatoes

The field experiments conducted at El Horno during the past year included a commercial varieties test, a fungicide test to control late blight, a comparison of cut potato tubers as seed with whole tubers, a comparison of late-blight-resistant potatoes and susceptible varieties with and without spray, a synthetic insecticide test to control the insect vector of the virus which causes purple top wilt, and an herbicide experiment. The last two experiments were carried out in cooperation with the entomology and herbicides programs, respectively. The breeding program to improve varieties for the high valleys, as well as criollo varieties for the mountains, now includes 15,000 clones from 50 different crosses which will be exposed to *Phytophthora infestans* for field resistance in the Toluca Valley during 1962.

In connection with the germ plasm bank, the wild species were reviewed to check the authenticity of the classified species, several new interspecific crosses were obtained, and some new collections were added. Among the most important ones were several frost-resistant clones of *Solanum demissum.*

One of the most important results of the basic research program was obtained from a study of tuber resistance of nine foliage-resistant varieties to late blight which showed that the varieties Dorita and Greta are highly resistant to *P. infestans* in the foliage and also in the tubers.

At the Santa Elena station, field experiments were conducted with fungicides to control *P. infestans* and on the use of fungicides in cut tubers used as seed.

The project of selecting clones resistant to *P. infestans* was continued. Of the 10,000 clones exposed to the disease in the Toluca Valley under field conditions during the summer of 1961, 39 resistant clones were selected. From the most advanced commercial material two outstanding new selections, 57 DZ-29 and 57 AH-9, were made.

The production of Mexican certified potato seed is of great importance in order to reduce importation of seed and to test under native conditions. The main problems in producing good certified seed in Mexico are the virus diseases. Since potato Virus X is carried by most foreign varieties, a study of this disease was initiated in order to determine whether the virus is present in the varieties that are planted in Mexico, particularly those widely used in the production of certified seed. The presence of Virus X was confirmed and a project is under way now to determine the effect of the virus on yield.

At Navidad, Nuevo León, the project of selection for resistance to "early blight" caused by *Alternaria solani* was continued, and selections which carry resistance to late blight as well as early blight were made. The purpose in exposing the late-blight-resistant selections to early blight is to combine field resistance to both diseases.

The late-blight-resistant varieties Anita, Bertita, Conchita, Dorita, Elenita, Eréndira, Florita, Gabriela, and Greta were planted in trials in the States of Puebla, Tlaxcala, México, Guanajuato, Michoacán, and Aguascalientes to study their adaptation in these areas.

The Mexican varieties resistant to *P. infestans* have been requested by institutions of the following countries: Turkey, Viet Nam, Honduras, Switzerland, and Czechoslovakia.

Hand pollination of an onion flower.

Horticulture

The research projects in horticulture have been enlarged to study more crops, at more locations, in order to obtain additional information regarding the best cultural practices for these crops in regions of agricultural importance. Work is also continuing on the development of better vegetable varieties with improved quality, productivity, and disease resistance.

Cooperative projects with the soil, entomology, and plant pathology programs continue in order to better define cultural practices which can improve production of horticultural crops.

Demonstration plots with the adapted vegetables have been established at all principal stations.

EL HORNO

In order to study general adaptation to this region, several plots were established with a group of 11 horticultural crops. Varieties outstanding in productivity and quality included the following: *Beets*—Ruby Queen; *Cabbage*—Market Master; *Cauliflower*—Snow Super Junior; *Carrots*—Monarch; *Snapbean*—Blue Market Stringless 7; *Sweet corn*—Burpee Honey Cross and NK-1304.

The evaluation of quality and productivity of different strains of Nantes carrots was continued. Nantes Improved Coreless of Asgrow and Scarlet Nantes of Northrup King rated best in over-all quality. These two varieties yielded 57.9 and 60.1 ton/ha., respectively. These results are consistent with previous years' data.

For the first time an observational plot was established with ornamental crops. Several varieties of zinnia, marigold, gladiolus, carnation, snapdragons, etc., were studied. Among the most satisfactory at this station were the marigold F_1 hybrids Alaska and Yellow Climax.

PEPPER

The main objective of the pepper improvement work is being reached, namely, the development of highly uniform lines of the Mulato type with good productivity, resistance to diseases, and high quality.

In parallel with this objective, improved lines of the Ancho, Mulato, and Güero types are being studied for future release. In the Ancho breeding project, 17 advanced and uniform lines were selected last year. Several of these, together with the experimental synthetic variety VSA-1, the experimental variety VA-1, and the local variety, have been placed in a comparative yield trial this year, for final trial before release of the best type as a commercial variety. A similar procedure is being followed in the improvement of Mulato pepper.

The study of the inheritance of the resistance to the root-rotting pathogen *Phytophthora capsici* has been continued in cooperation with the plant pathology program. This study is being conducted with representative materials of Ancho, Mulato, Pasilla, Güero, and Jalapeño.

A fertilizer and spacing study was conducted with Mulato pepper. The data have not been completely analyzed, but the preliminary results indicate that maximum yields were obtained when rows were spaced 92 cm. apart with 30 cm. between plants and 80.5 kg./ha. of nitrogen and 57 kg./ha. of P_2O_5 were applied.

SQUASH

The biosystematic study of this crop has been continued. There are four main objectives: (1) taxonomic identification and measurement of the inter- and intraspecific variability; (2) recognition of the phytogenetic relationships; (3) determination of the direction and intensity of genetic infiltration; and (4) study of the inheritance of horticultural characters of economic importance.

On the occasion of their visits, Dr. T. W. Whitaker and Dr. H. G. Cutter were very helpful in evaluating and observing certain materials on which the classification was doubtful.

SANTA ELENA

In a spacing experiment with the adapted celery variety Utah Tall Green, spacings of 30 and 40 cm. between plants in rows 75 cm. apart gave the best results in terms of height, diameter, and weight of the individual head.

Irrigating lettuce for seed production.

The improvement project on horsebean, which was started three years ago, reached the point last year where a selection plot was established with 185 advanced lines. Out of these, 26 mass selections and 56 individual plant selections were made. The selected material shows a high degree of uniformity, resistance to the common diseases in the area, high productivity, and resistance to lodging.

TEPALCINGO

TOMATO

The best selections from previous years' work on firm fruit material were crosssed with a group of 20 tomato varieties with the objective of improving the fruit firmness in the commercial varieties.

Since the activity of pollinating insects is high in the area, further evaluation was made of the intensity of the natural cross-pollination in tomatoes. The results obtained verify the observations of previous years.

CUCUMBER

A breeding project has been started to develop types with resistance or tolerance to powdery mildew, caused by *Erysiphe cichoracearum* De Candolle. Blanco de Tehuantepec, a collection which produces fruits of poor quality and white color but has shown a high degree of tolerance to the disease, was crossed with the adapted commercial varieties Palmetto, Palomar, Stono, and Marketer. At the same time, advanced selections from crosses made in 1957 at Cotaxtla between the resistant Japanese variety HODAI and a group of commercial varieties were tested at Tepalcingo. These materials are in the F_3 and F_4 generations and show good horticultural qualities, with good tolerance to the disease. Individual plant selections were selfed and will be further evaluated next winter.

HOME GARDEN PLOTS

More varieties of different vegetables were evaluated and the following can be added to the list of recommended varieties for the home garden: *Chard*—Fordhook Giant; *Beet*—Crosby's Egyptian; *Radish*—Crimson Giant; *Yellow onion*—Texas Grano 502; *Snapbean*—Tendergreen and Stringless Black Valentine; *Cabbage*—Copenhagen Market; *Summer squash*—Zucchini; *Eggplant*—Long Purple; and *Cauliflower*—Early Snowball X.

CULIACAN

Two plots of genetic materials of tomato were established, one consisting of 131 lines with some resistance to the late-blight fungus, *Phytophthora infestans*, and the other of 121 lines with firm fruit. Selections were made in both and the materials will be further evaluated, to be used later in the improvement of the varieties grown commercially for the export market.

Observation plots were established to study the adaptation of a number of varieties of watermelon, cantaloupe, and cucumber.

LOS MOCHIS

In the onion breeding program, which was initiated two years ago at CIANO, yellow, purple, and white varieties are being selected and improved. Last year 150 individual bulb selections of the variety Texas Grano 502 were selfed, and 32 S_1 lines of purple onion and 52 S_1 lines of the white Cojumatlán were planted for bulb production and selection.

To study the adaptation of a large number of varieties of the species adapted in the area, observation plots were established with 13 pepper varieties, 12 watermelon varieties, 11 cantaloupe varieties, 10 cucumber varieties, and 3 sweet corn hybrids.

At the same time, to define the best planting dates for different crops, a study was begun which includes 11 crops and 29 varieties, planted monthly.

EL ROQUE

Observation plots were established with 32 horticultural crops to study their adap-

TABLE 1.

Yield, in kg./ha. of dry product, of six advanced lines of Ancho pepper. Pabellón, 1961.

Line	Yield
A-1256	6,637
A-1297	6,073
A-2001	5,849
A-1185	5,414
A-1225	5,081
A-247	5,000

tation. The results are being published in a regional bulletin.

TOMATO

In an observation trial with 31 STEP lines, the best were lines 362, 371, 372, 375, 376, 379, 381, 382, 383, 384, 389, and 390. In a replicated yield trial, STEP 352 was outstanding in quality and yield (30.1 ton/ha.).

A total of 139 advanced lines with resistance to late blight were planted for evaluation. In spite of a heavy hailstorm, some 16 promising individual plant selections were obtained.

A plot with firm fruit lines was established, and 46 individual plant selections were made.

ONION

The objectives of this project are: (1) formation of uniform, open-pollinated lines with resistance to premature bolting; (2) high productivity of bulbs with acceptable horticultural quality; and (3) resistance to diseases, both in the field and in storage.

Selfed seed was obtained in 45 lines. Fifty-two S_1 lines from CIANO also form part of the project.

PEPPER

Nine pepper types were represented in observation plots, in which selected plants were selfed.

Selections from the program at Santa Elena were brought to El Roque and observed in plantings established last winter. Fifteen lines were mass selected, while 23 individual plant selections were made.

PABELLON

During 1961, 23 plots with different breeding materials of pepper were established. These materials consisted of advanced lines of Mulato, Ancho, Pasilla, Guajillo, Puya Corta, Catarina, De Arbol, Cora, Cascabel, Jalapeño, Serrano Balín, and Serrano Tabaquero. Some of these, mostly of the sweet and pimento types, are new to the area.

The following basic objectives are being sought for each type of pepper: development of uniform, high-yielding varieties; resistance to the most important diseases, particularly those causing root rots, such as *Phytophthora capsici*, *Fusarium*, and *Verticillium;* and high quality, in the green as well as in the dehydrated stages.

Within the most important types, there are already some outstanding materials. The results of a yield trial with six advanced lines of Ancho are given in Table 1.

The statistical analysis showed that the average least significant difference was 827 kg./ha. of dry pepper. These yields are far above the average obtained with the local varieties, which is about 2,500 kg./ha. of dry pepper. During 1962 the evaluation will be repeated, against the best local types, as a probable final step before the release of the best lines as commercial varieties.

COTAXTLA

TOMATO

Thirty-two STEP lines were evaluated in an observation plot. The best in adaptation, foliage cover of the fruit, and yielding capacity were lines 322, 350, 356, 370, 381, 386, 388, and 392.

A replicated yield trial with advanced STEP lines and several varieties confirmed the yielding capacity of Cotaxtla 1 and indicated the value of several other STEP lines for tropical production. Results of this trial are presented in Table 2.

TABLE 2.

Yield, in kg./ha., of varieties and STEP lines of tomato. Cotaxtla, 1961.

Variety or line	Yield
STEP 361	26,353
STEP 352	24,660
STEP 341	24,546
Cotaxtla 1	24,080
STEP 329	20,260
Manapal	19,926
Homestead 24	19,466
STEP 346	18,753
Marion	18,393
STEP 348	17,800
Rutgers	15,740
L.S.D. 5%	5,907
1%	7,756

In addition to productivity, other characteristics were evaluated, such as resistance to leaf mold (*Cladosporium fulvum* Cke.). STEP 361 showed a high degree of tolerance to this disease, a factor which may account for the high yield obtained. However, the variety Marion, which last year performed better than Cotaxtla 1, this year ranked much lower.

PEPPER

The improvement program is devoted to the two most important types in the region, Jalapeño and Serrano. In the latter, the material selected previously was studied more carefully this year and individual plant selections and selfing were made in four main groups or types, provisionally named Chato, Gordo, Delgado, and Típico.

Response of corn to application of chicken manure, La Cantera, Michoacán.

Soil Fertility and Management

The research program in soils is devoted to the study of soil management practices which are economically advantageous to farmers and result in sustained high soil productivity. The use of chemical and organic fertilizers, residual effects of cropping systems and other management practices, and efficient use of irrigation water are the three fields receiving major attention at present.

Field experimentation in 1961 was carried out at the El Horno, Cotaxtla, CIANO, Torreón, El Roque, and Río Bravo stations as well as in cooperation with farmers in the States of México, Michoacán, Guanajuato, Veracruz, Sonora, and Coahuila. Most of the soil fertility and irrigation studies were carried out with corn, wheat, and cotton. The crop rotation studies included other crops of local importance such as beans, sesame, soybeans, sorghum, and alfalfa.

Soils laboratories located at El Horno, CIANO, Torreón, and Río Bravo were employed to analyze soil and plant samples from the field experiments and contributed appreciably to a more adequate interpretation of the results of these studies. Greenhouse facilities at El Horno were used to supplement and broaden the field studies on the use of fertilizers.

USE OF FERTILIZERS

The field determination of crop response to applications of fertilizers for specific productivity systems is the basic method employed in arriving at fertilizer treatments that farmers should use in their plantings. The determination of fertilizer recommendations for irrigated crops like wheat and cotton is relatively simple, since the productivity factors other than available nitrogen, phosphorus, and potassium are usually adequate for reasonably good growth. Corn, on the other hand, is largely grown without irrigation, and soil moisture is a limiting growth factor of variable intensity in most plantings. Consequently, the study of fertilizer recommendations for corn continues to receive considerable attention at all the experiment stations and constitutes about 75% of the work carried out cooperatively with farmers.

A study conducted in the region of Piedras Negras, Veracruz, illustrates the tremendous importance of chemical fertilizers in increasing corn production in areas with near adequate rainfall. Five experiments were conducted in which the effects of four rates of nitrogen (0, 40, 80, 120 kg./ha.), four rates of phosphorus (0, 40, 80, 120 kg./ha. P_2O_5), and three rates of potassium (0, 40, 80 kg./ha. K_2O) were determined. Grain yields without fertilizer varied from less than 1 to almost 3 ton/ha. Yields were influenced by the fertilizer treatments in a similar manner at all locations. The average increase in grain yield from the application of 40 kg./ha. of nitrogen was 1.42 ton/ha., or 35 kg. of grain per kg. of applied nitrogen. The effects of the second and third increments of 40 kg./ha. of nitrogen were yield increases of 1.26 and 0.67 ton/ha., respectively. On the average, the application of 120 kg./ha. of nitrogen increased grain yields from 2.37 up to 5.72 ton/ha. Yields were also increased considerably by phosphorus applications but were not affected by additions of potassium.

A similar study on the fertilization of unirrigated corn was carried out in the State of Guanajuato. Rainfall was extremely variable at the several experimental sites, and drought was so severe at one-third of the locations that the corn with or without fertilization failed to produce grain. In the other experiments applications of nitrogen alone or nitrogen plus phosphorus resulted in small increases in grain yields. The problem of determining under what conditions unirrigated corn yields can be increased economically by fertilization is a complex one and will receive more detailed study in the future.

IRRIGATION PRACTICES

Irrigation studies conducted prior to 1961 indicated on the basis of extrapolated data that the deep, heavy clays in the vicinity of Valle de Santiago, Guanajuato, should receive three irrigations for optimum wheat production, and that the somewhat lighter clays in the same area should receive four irrigations. Experiments were conducted in 1961 at six locations to verify the above conclusions. On the basis of the soil properties at each site the optimum number of irrigations was estimated, and the irrigation practice employing this number of irrigations was compared with (a) one which included an additional irrigation and (b) the customary irrigation practice of the farmer. In four experiments, the estimated number of irrigations resulted in wheat yields equal or superior to those obtained with the other irrigation practices studied. In two experiments, one irrigation more than the estimated optimum was necessary to obtain the highest yields. Evidently the technique which has been used in estimating the optimum number of irrigations for producing wheat in different soils is fairly precise, although other soil properties affecting water movement (e.g., soil permeability) will undoubtedly have to be taken into consideration.

The study of the optimum irrigation practice for cotton in the Yaqui Valley was continued in 1961. Irrigations were applied when the available soil moisture in the 0-30 cm. horizon was reduced to 72%, 36%, 18%, and 0%. The total amounts of water applied in the four treatments were equivalent to layers of 209, 152, 140, and 110 cm., respectively. With adequate fertilization yields of seed cotton in the four treatments were 2.18, 3.03, 3.22, and 3.04 ton/ha., respectively. Considering the fact that in the Yaqui Valley the factor limiting the number of hectares under irrigation is the amount of water available for irrigation and not the area of good soil available, it appears that the driest treatment is the most adequate for the region.

RESIDUAL EFFECTS OF MANAGEMENT PRACTICES

Experiments in which important cropping systems are being compared have been in progress at El Horno, CIANO, and Cotaxtla for four to six years. Changes in soil properties in the different rotations have not been analyzed in detail, but some differences have become apparent. The tilth of the soil at El Horno is noticeably improved by a three-year period in alfalfa. When the soil at this station is planted to Hubam clover during the summer months, the population of noxious weeds is increased. The cropping system in which wheat occupies the land in the winter and beans in the summer has shown a decline in bean yields after the third year, probably because of a build-up in the soil of root-rot organisms which attack the beans.

Variations in crop yields associated with different ways of disposing of the residues of the preceding crop have been measured at CIANO for a period of six years. When the crop residues are incorporated into the soil, the nitrogen for the following crop is applied in three ways: all at time of incorporation; half at time of incorporation and half at time of planting the following crop; and all at time of planting the following crop. It was found that wheat yields following the incorporation of cotton residues were 22% higher when the nitrogen fertilizer was applied at time of turning under the cotton stalks instead of at time of planting the wheat. Corn yields following wheat, however, were 14% lower when the nitrogen was applied at time of turning under the wheat straw instead of at time of planting the corn. The exact reason for this difference is not known, but it is related to the degree of decomposition of residues which occurs between the harvest of one crop and the planting of the following, distance between rows of the succeeding crop, and degree of weed competition for the nitrogen applied at time of incorporating the residues.

Evaluating pink bollworm infestation in experimental cotton plots at Torreón.

Entomology

The research program in entomology is directed toward a better understanding of the incidence of insect pests and their fluctuations, estimation of the losses which they cause, selection of sources of resistance to insect attack, evaluation of the effectiveness of insecticides, the frequency with which they must be applied, and their residual action, and basic information on the biology of pests which is indispensable for the development and integration of control methods.

STUDIES ON PEST INCIDENCE

With respect to the incidence and fluctuation of pests, it may be pointed out that while many of the pests have been identified, the factors that determine their incidence and seasonal fluctuation of their population are not exactly known. In order to explore this aspect and to evaluate the importance of the corresponding pest, studies have been carried out to establish the influence of planting date on pest incidence in horticultural crops and cotton. Taking into consideration the incidence of the pink bollworm, *Pectinophora gossypiella* Saund., these observations confirm the fact that the best planting date for cotton in the La Laguna region is the first fortnight in April. The pest incidence in other crops has been estimated through periodic observations at experiment stations and in farmers' plots.

These observations emphasize that, because of the great diversity of agricultural pests, detailed surveys must be carried out, coordinating the efforts of the agricultural schools, the Bureau of Plant Protection, and INIA. They show likewise that it is imperative to establish weather stations strategically located to provide appropriate information useful in interpreting the fluctuation of pest populations.

CHEMICAL CONTROL STUDIES

Apart from the loss estimations obtained through routine experimentation with insecticides, an experiment specifically designed to measure losses in cotton was carried out at CIANO. This study showed that an early attack of the boll weevil, *Anthonomus* sp., and the bollworm, *Weliottus* sp., at levels that could damage 20%, 40%, or 60% of the squares and bolls, would reduce yields by 0, 7%, and 23%, respectively; a late attack at the same damage levels would cause yield reductions of 17%, 27%, and 31%, respectively. With a production average of 2.2 ton/ha., 7% would represent 157 kg. and 31%, 682 kg. If the average price per kg. of fiber and seed is 2.00 pesos, in the first case the expense of two applications (100.00 pesos per application) would be justified, and in the second case that of four or six to prevent population increase and impede larger losses. Once this type of information has been obtained on other pests that limit the production and in other cotton zones of the country, it should be possible to decide at what infestation levels chemical control is justified and so avoid unnecessary applications.

During the year 11 tests were carried out to determine the effectiveness of 22 insecticides, 4 tests to determine the residual action of several of these materials, and one to estimate the frequency with which Sevin must be applied to control cotton pests. In a cooperative test with the potato program at El Horno, the application of granulated thimet (3.0 kg./ha.) before seed-time reduced the incidence of purple top, a virus disease, by 66%; this effect was reflected in a 28% yield increase. In addition, the population of some sucking insects, possible vectors of the virus, was considerably reduced. This information may be useful in the production of certified seed potatoes as well as in reducing the incidence of purple top in zones where this disease is a limiting factor. In two similar experiments carried out at León, Guanajuato, the incidence of the disease was almost nil, but it was nevertheless possible to detect the effect of thimet in the reduction of the population of such sucking insects as thrips, leafhoppers, white flies, and flea beetles.

Another study of special significance was that carried out at Torreón, Coahuila, which confirmed the resistance acquired by the pink bollworm to DDT. Such resistance has been reported to be 13 times larger than that of susceptible populations.

Tests conducted in the field at El Horno, Cotaxtla, and Torreón to evaluate the residual action of several insecticides used to control bean and cotton pests, revealed that in both crops at all stations Sevin caused an average mortality of 80% seven to nine days after application. Lindane and DDT, alone or mixed with methyl parathion or thiodan, caused a similar mortality within two or four days after application. Other insecticides included in these tests were Diazinon, malathion, BHC, and methoxychlor.

One of the factors that may considerably raise the production costs of cotton is pest control. In 1961 the average number of applications in the Yaqui Valley, Sonora, was one or two, while in other cotton zones of the country the average varied from six to 16. In the La Laguna region up to 12 to 15 applications are frequently used; however, results obtained at Torreón indicate that eight or nine applications at intervals of eight to nine days are adequate to combat the pests. This average can probably be reduced even more if recommendations for planting date, destruction of crop residues, and other sanitation measures are followed.

BIOLOGICAL CONTROL STUDIES

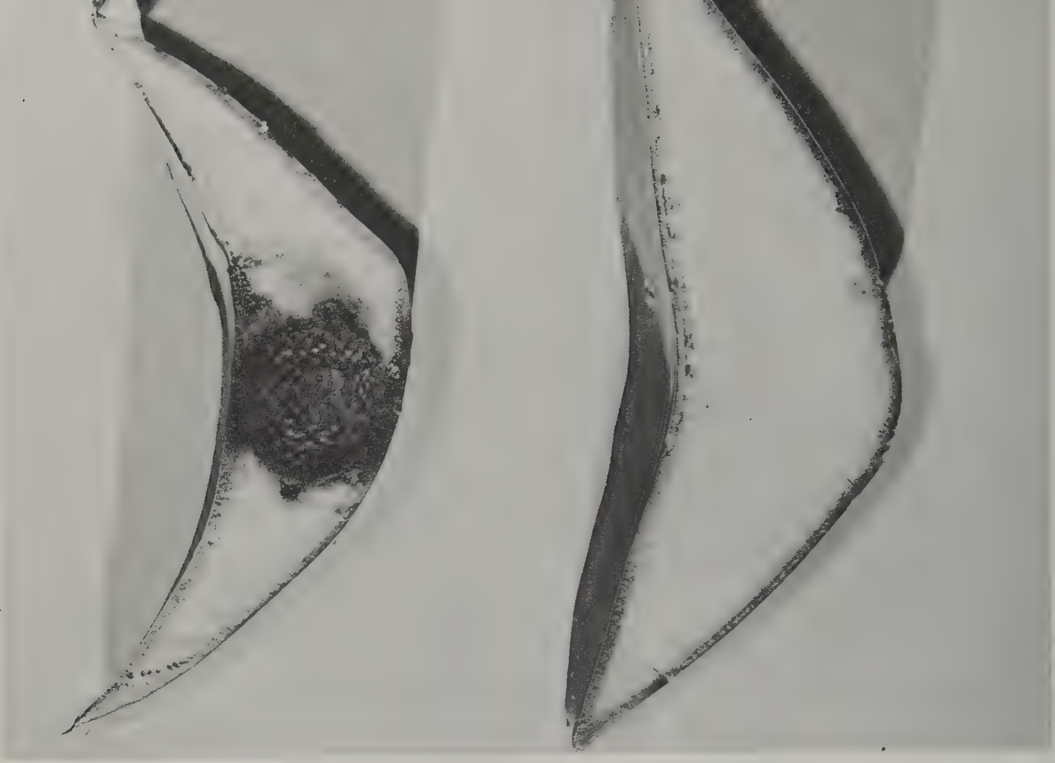
In a study at El Horno on the control of the Mexican bean beetle, *Epilachna varivestis* Muls., by means of resistant varieties, evaluations have been made of 404 varieties of *Phaseolus vulgaris*, 12 of *P. coccineus*, and 12 collections each of *P. mungo* and *P. aureus*. From these, selections have been made under greenhouse conditions of 30 varieties of *P. vulgaris* which have shown tolerance to the attack of this pest.

In a test performed under field conditions at CIANO, none of five soybean varieties exhibited tolerance to the attack of the thrip, *Hercothrips phaseoli* (Hood).

BIOLOGICAL STUDIES

Basic studies consisted in determining the length of the life cycle of the following insects: the Mexican bean beetle, *E. varivestis*; the potato tuber moth, *Gnorimoschema operculella* (Zeller), which in 1961 damaged almost 50% of the tubers in many potato fields at León, Guanajuato; the fruit and twig borer, *Stenoma catenifer* Wals., which destroys 60% to 80% of the fruits in the central and southern zones of Tamaulipas; the cutworm, *Agrotis malefida* Guen., one of the main species of the group in the Yaqui Valley; and the corn leafhopper, *Dalbulus maidis* (De L. and W.), vector of the corn stunt virus.

The study, under field conditions, of the life cycle of *E. varivestis* has furnished some valuable information for the application of the method of control based on the liberation of insects sexually sterilized by means of gamma radiations. Preliminary tests have been made for the purpose of estimating how much irradiation of the eggs of the beetle is necessary to obtain sexual sterilization in the adults. It was found that the median lethal dose ranges between 100 and 200 roentgens, which is smaller than that reported for other pests.



Foot rot of agave induced by *Chalaropsis* sp. *Left*, inoculated leaf; *right*, check inoculated with sterile water.

Plant Pathology

During 1961 research activities in plant pathology consisted of three types of projects: (1) cooperative research on disease problems with the various plant improvement sections of INIA; (2) basic research on phytopathological problems affecting agricultural crops in Mexico; and (3) provision of information and recommendations to Mexican farmers on the identification and control of plant diseases. Some of the more outstanding results are described below.

In cooperative work with Dr. Arnold Ullstrup, U.S.D.A. plant pathologist stationed at Purdue University, the nature and identification of the pathogen causing the "horse's tooth" disease of corn was determined. This unusual disease is caused by a fungus belonging to the genus *Sphacelia*, which has a form of *Claviceps* as its perfect stage. This is the first report of this disease in Mexico. Indeed, it is relatively unknown, and it is uncertain whether it is quite new or perhaps the same as a disease reported in Argentina many decades ago. While this corn disease does not cause great damage in Mexico at present and is limited to the cool, moist highland region, it is a good example of an obscure disease that is of potential importance on new selections and varieties.

Basic investigations were continued on the physiologic variation in the fungus *Phytophthora infestans*, the cause of the late-blight disease of potatoes. A group of cultures of the fungus, representing several physiologic races, were grown mixed in a single petri dish. From asexual sporangia which were collected from intermingling cultures, new monozoosporic cultures were obtained which differed in pathogenicity from the original races used. These new races were produced without the intervention of the sexual oospore stage. Studies were conducted on the possible explanations for this variation observed, and there is evidence that parasexual fusions are playing a role, although heterocariosis cannot be excluded.

At the El Horno laboratory 261 plant disease specimens were identified and, where indicated, recommendations for control were given to the farmers concerned. Some of these cases were the first reports of these diseases in Mexico, and specimens were deposited in the cryptogamic herbarium.

For the first time an exhaustive study was made of a basal rot disease of maguey (*Agave* sp.) in the region of Huamantla, Tlaxcala. This disease is of considerable importance in the pulque-producing states of Tlaxcala, Puebla, and Hidalgo. Diseased specimens repeatedly yielded a fungus, tentatively classified as a species of *Chalaropsis*. Inoculations with pure cultures on maguey plants growing in plantations in Huexotla and Río Hondo, México, reproduced typical symptoms of the disease. Control measures have not yet been worked out. There are indications, however, that the fungus is introduced into the plant by an insect larva which bores into the flesh of the thick leaf base. Control of this insect might thus give control of the basal rot organism.

In the region of Martínez de la Torre, Veracruz, a series of experiments was conducted to determine resistance to leaf blight, *Helminthosporium turcicum*. Of the collection of corn races exposed to severe field infection, Comiteco was outstanding for its resistance. Among the basic breeding lines, T-6 showed a high level of tolerance and great promise as a source of resistance to this important tropical corn disease.

Research on the resistance to corn stunt in tropical corns showed that there is a high level of susceptibility in the basic lines now being utilized in the formation of hybrids commercially distributed in this area. The breeding line T-11 showed the highest degree of tolerance to the disease, but it could not be considered as resistant. H-507 is one of the more resistant hybrids, while H-503 and H-504 are among the most susceptible.

At CIANO studies were conducted on the wheat disease known as "black point." Since the cause was unknown, the sudden appearance of the disease has created considerable alarm among farmers in this important wheat-growing region. Indications are that the trouble is caused, at least in part, by a species or group of species of *Alternaria*, which do not affect germination. The variety Lagunera 58 showed no damage from the disease at all, while Cajeme 60 was the variety most severely affected.

Another possible cause of black point is the fungus *Helminthosporium*, and here also several species may be involved. *Helminthosporium* does affect the germination of the wheat, and for this reason it was recommended that wheat seed affected with black point be treated with mercury-based seed treatment fungicides.

The tassel- and head-smut disease of corn, caused by the fungus *Sphacelotheca reiliana*, was the subject of a series of experiments in the Bajío region where the disease continues to be troublesome. Control by seed treatment and cultural practices appears to be ineffective, and soil treatment with chemicals, even at double the rate recommended by the manufacturers, failed to give satisfactory control. Since there are wide differences in resistance among the lines available to the corn breeders, utilization of resistant lines in the formation of new hybrids and varieties appears to be the only practical method of controlling the disease. The Mexican corn races Conico, Chalqueño, and Cacahuacintle, all from the higher altitudes, constitute the best available sources of resistance.

Control of weeds in rice with STAM F-34.

Herbicides

In many of the principal agricultural areas of Mexico, there is a period of intense rainfall at the beginning of the growing season which makes it difficult to use mechanical tools for adequate weed control. In these areas, weeds are the physiologically and economically limiting factor in crop production. Investigations to determine the most appropriate methods of weed control come under two main categories: (1) botanical and ecological research to classify the weeds, determine their distribution, and establish the degree of weed competition, the critical period of competition, and the germinative and other properties of weed seeds; and (2) studies on weed control practices in field and horticultural crops, the control of brush and weeds in non-crop land, and the elimination of special weeds.

Botanical and Ecological Investigations

COLLECTION AND CLASSIFICATION

Weed collection and classification were initiated in 1961 at Cotaxtla. Consideration is being given to the main morphological characteristics related to weed control, such as plant form, leaf shape, leaf position and density, leaf surface and margins, and the form, shape, size, density, distribution, and other characteristics of the roots. To date about 30 species have been classified. This collection will aid in the rapid identification of weeds and provide the basis for the formation of a reference herbarium.

WEED COMPETITION STUDIES

These studies were conducted to determine the competitive ability of annual mono- and dicotyledonous weeds with crops. The results of two years show that broad-leaved weeds are stronger competitors in corn than are grasses. Both types of weeds sharply reduce yields of beans, although broad-leaved weeds are slightly more severe. In rice it was found that competition from either mono- or dicotyledonous weeds completely eliminated the rice stands after one year.

In the wet tropics it is common to find weed stands ranging from 500 to 1,000 plants per square meter growing along with crops, the highest weed population generally being observed from 20 to 30 days after planting. With corn and beans, yield reductions due to weed competition are greater when weeds compete during the first 30 days after planting; however, if the weed stand is mainly formed of broad-leaved weeds, especially *Amaranthus* spp., the critical period of weed competition is restricted to the first 15 to 20 days of crop development. In rice, the critical period appears to be the first 20 days after planting.

STUDIES ON SPECIAL WEEDS

Studies were started at Cotaxtla in 1961 on the reproduction and growth of some weeds considered to be serious problems. *Cyperus rotundus* L. has been selected for the initial study because of the many crop lands heavily infested by this weed and also because its control is very difficult by mechanical or chemical means. Under investigation are the factors involved in the germination of tubers and seeds, depths of planting of tubers, and tubers produced by a single plant at different time intervals.

WEED SEEDS

In a study on weed seeds, begun in 1961, soil samples are being taken at different depths each year from the experiment stations. One kilogram of soil is dried and sieved, and the weed seeds are then separated, counted, and classified according to families and species when possible. This study will give the information and material required to evaluate the changes in the amount of the different weed species in the soil, to study the factors involved in germination of the seeds, and to determine the degree of susceptibility of seeds to herbicides.

WEED CONTROL PRACTICES

CORN

High weed stands observed in corn plots were mainly formed by broad-leaved weeds, among which *Spilanthes filipes* and *Borreria* spp. made up 90% or more of the population.

Diuron, CDAA + 2,4-D, and trietazin were the most promising of the new herbicides tested, although slight damage was observed on the corn treated with diuron and the mixture CDAA + 2,4-D. Experiments conducted for two years on the evaluation of band sprays of chemicals in association with different numbers of cultivations have shown that the most economical method of weed control in corn is the association of one mechanical cultivation with pre-emergence applications of either simazin, 2,4-D, or the mixture 2,4-D + DNBP in 30-cm. bands over the row.

At Cotaxtla, the rate of disappearance from the soil of two of the more common herbicides for corn was determined by means of a bioassay test. The results obtained established that 2,4-D, at rates up to 4 kg. active ingredient per ha., disappears almost completely from the soil within 20 days after application; however, simazin at 4 kg. active ingredient per ha. remains on the upper 5-cm. layer of soil, at concentrations toxic enough to reduce the stand and growth of sesame by 50%, for a period of 40 days. Beans were not affected by residues of either simazin or 2,4-D at any rate, and the yields were as good as those from the hand-weeded plots.

As might be expected on tropical soils, the toxic residues of the herbicides last no longer than the period of corn development, and there is apparently an adequate margin of security when susceptible crops follow corn in a rotation plan.

BEANS

Several experiments were established during 1960 and 1961 at Cotaxtla to evaluate the action of different herbicides on bean production. In an experiment conducted in 1960 under scanty rainfall conditions, amiben and, to a lesser extent, CDAA liquid or granular were the most promising for their effectiveness in weed elimination and non-toxic effect on the crop. In 1961, the same herbicides were evaluated under heavy rainfall conditions. Amiben gave excellent weed control and did not damage the beans. NPA-3, either alone or mixed with CIPC, effectively controlled most of the annual weeds but caused some damage to the beans which reduced yields. CDAA, CIPC, and DNBP gave poor control of annual weeds, especially grasses.

Two other experiments were established to determine the effectiveness of mixtures of herbicides and to compare the liquid and granular formulations of amiben and CDAA. Excellent weed control was obtained with all the mixtures tested—DNBP + CDAA, DNBP + CIPC, and CDAA + NPA-3—but again some damage was noted with the mixture that included NPA-3 and yields were reduced (Table 1). Among the weeds observed, only *Trianthema portulacastrum* L. was slightly resistant to all the mixtures tested. The greater effectiveness of the mixtures of the herbicides over the same herbicides alone was well demonstrated.

Amiben in either granular or liquid form almost completely eliminated mono- and dicotyledonous weeds for more than 30 days. On the other hand, CDAA in both forms was relatively ineffective as an individual herbicide.

RICE

Previous studies have shown that avadex and randox-T are promising as herbicides on rice; however, results are variable from one year to another. In 1961, these herbicides were re-evaluated in a test that included STAM F-34. The best control was obtained in the plots treated with STAM F-34 when the weeds were at the two- to four-leaf stage of growth. Among the weeds eliminated by STAM F-34 were *Echinochloa colonum*, *Panicum* spp., *Scleria* spp., *Thalia* spp., *Amaranthus* spp., *Stizolobium pruriens*, and *Croton* spp.

POTATOES

In cooperation with the potato improvement program, an experiment was established in 1961 at San Martín, México, to

TABLE 1.

Effects of pre-emergence over-all applications of three herbicide mixtures on beans. Cotaxtla, 1961.

Treatment[a]	Effect on[c]			Yield of beans (kg./ha.)
	Beans	Grasses	Broad-leaved weeds	
DNBP + CIPC				
1.5 + 1.0[b]	00	77	81	1,839
3.0 + 2.0	00	90	93	1,980
DNBP + CDAA				
1.5 + 1.0	00	87	89	1,895
3.0 + 2.0	00	82	84	1,914
CDAA + NPA-3				
1.0 + 1.0	20	91	92	1,330
2.0 + 2.0	35	93	93	1,259
Checks:				
Cultivated 3 times	—	—	—	1,785
Weedy	—	—	—	865
			L.S.D. 5%	443
			1%	603

[a] Plots treated with herbicides were cultivated for 20 days after the application.

[b] Kg. active ingredient/ha.

[c] Scale of 0 = no apparent effect, 100 = all plants killed.

evaluate the effectiveness of different triazine derivatives, monuron, and DNBP. The results, in terms of percentage weed control, degree of crop damage, and yields, were favorable to monuron (0.75 kg. active ingredient per ha.), DNBP at rates up to 1.5 kg. active ingredient per ha., and trietazin at rates up to 3 kg. active ingredient per ha. The yields obtained with these treatments were not significantly different from those obtained in check plots cultivated mechanically three times. Simazin, atrazine, and higher rates of monuron, although effectively controlling annual weeds, caused severe damage to the crop which was reflected in yield reductions. It was observed that the competition of weeds growing in the rows reduced the yields of potatoes by about 50%.

BRUSH CONTROL

Brush and weeds are a great problem in most of the grasslands of Mexico and contribute to the low yields and poor quality of certain livestock products. The common methods of control—fire, cutting, or both—have not been effective.

In 1959, a study was initiated at Cotaxtla to evaluate herbicides for the control of *Mimosa pigra*, a plant that grows more than 3 m. tall with about 1.5 m. of roots. It is found on most of the lowlands along the coast of the Gulf of Mexico, in stands as dense as one plant per sq. m. The results of these experiments indicated that the best herbicides were silvex and the ester formulations of 2,4-D and 2,4,5-T applied at the rate of 0.5 kg. active ingredient per 100 liters of water between 45 and 60 days after the plants were cut and burned. The percentage control obtained one year after the applications varied from 95 to 100.

These results were verified in an experiment conducted in 1960 which involved chemical control of *Mimosa* and the establishment of paragrass and Aleman-grass one month after the application of the herbicides. Excellent control of *Mimosa* was obtained with all the herbicides. Satisfactory, rapid grass establishment was observed on the plots planted with para and, to a lesser extent, with Aleman.

On the basis of these results, silvex and 2,4,5-T were applied to a mixed brush on a grassland. Observations made six months later showed that most of the brush species were well controlled or eliminated by these chemicals.

CONTROL OF SPECIAL WEEDS

Different derivatives of phenoxyacetic acid and ATA were evaluated for control of *Cyperus rotundus*. The tubers of this weed were maintained in water for 12 hours to assure uniform germination and growth and then planted in waxed paper pots. The plants were sprayed with the chemicals at different stages of growth. The results obtained after three months indicate that *C. rotundus* growing under irrigated conditions can be effectively controlled by either MCPA amine or ATA at rates as low as 2 kg. active ingredient per ha. applied at the two- to four-leaf stage of growth. 2,4-D amine followed closely in effectiveness, while the esters of 2,4-D and 2,4,5-T were least effective.

In an experiment conducted under rainfall conditions, the effectiveness of these herbicides was reduced, but again the most effective herbicide was the amine salt of MCPA, followed closely by 2,4-D amine. The least effective were 2,4-D ester, 2,4,5-T ester, and ATA.

These results indicate the possibility of controlling *C. rotundus* by repeated applications of either the amine salts of MCPA or 2,4-D, at rates of 2–4 kg. active ingredient per ha. when the plants are at the two- to four-leaf stage. The same herbicides, mixed with surface active agents, will be evaluated this year.

Turkey nutrition studies with ladino clover.

Poultry

The evolutionary pattern traced by the poultry industry of the United States seems to be occurring in Mexico on a smaller scale and within a shorter period of time. The most noteworthy change is in the size of the poultry operations. Many persons who started poultry farms at a time when the price picture was all too favorable have now deserted their farms, disillusioned and with their savings gone. The rather large profit margin has narrowed to the point of disappearance, a fact that discourages investments. In reality, though profits have diminished, they are more realistic and require of the poultryman much closer attention to the application of modern technical methods.

Also apparent among the changes taking place is the disappearance of many small hatchery and feed mill businesses. Competition in these activities has become rather sharp, placing the small operator at an economic disadvantage. However, one trend in the opposite direction seems to be taking form: many requests have been received from poultrymen for information on farm feed preparation. Caution must be exercised in making such recommendations because economies cannot be assured and quality of feed may be variable. Nevertheless, the poultryman, hard pressed to reduce costs, can with proper care realize considerable savings on feed, which is the largest single cost factor in the poultry operation.

The work of this program with turkeys, which expanded considerably during the past year, has stimulated a good deal of interest. The Mexican authorities have initiated a program of turkey propagation based upon the experience of the research work in progress at the Santa Elena station. Though the relative growth of domestic commercial turkey production has been appreciable in the last three years, there is still considerable room for improvement.

Probably the most noteworthy achievement of the poultry research program during the past year is the work carried out with a natural pigmenting agent which can give the desired color to the skin and egg yolks of poultry.

MANAGEMENT STUDIES

One of the aims of the Mexican government is to improve the quality of rural livestock. The usual procedure is to introduce current commercial strains or varieties either to supplant or to "breed up" the local or indigenous (criollo) populations. Not enough thought is given, however, to improvement of the management of these animals or to their acceptability to the rural population. In an interesting demonstration of the relative worth of criollo and improved chickens under "native" and improved management, the importance of the interaction of environment and genetic constitution was quite apparent. The data obtained from this study indicate quite clearly that under native conditions the criollo chicken is more capable of coping with the adverse environment than the improved varieties. In other words, improved strains can produce a greater quantity of product more economically as long as favorable conditions are provided under which their inherited capacity may be expressed. In an adverse environment, improved poultry do not perform well.

It is important for poultrymen to know what influence, if any, the hatching date of their flock has on the age at sexual maturity and total egg production, and to know how to properly manage flocks hatched at different times of the year in order to obtain maximum efficiency in their production. In an experiment involving approximately 1,800 laying hens and conducted at Cotaxtla (sea level) and Santa Elena (high altitude), it was found that during a 12-month period egg production is generally best among chickens hatched from December to June. It was also apparent, however, that good performance can be obtained from chickens hatched at any time. Egg production was superior on the average at Cotaxtla, an observation that confirms others made earlier. The age at sexual maturity was variable but without any specific trend.

NUTRITION STUDIES

Normally poultry diets are composed of grains for energy, various materials of plant and animal origin for protein and vitamins, a source of minerals, and other minor but important ingredients. Work done by this program in previous years has shown that garbanzo (chick-peas) can be used as a practically complete diet and requires only minor supplementation. A study was conducted utilizing garbanzo at levels up to 86% of the laying ration. A factorial experiment was designed using three levels of protein and four levels of blood meal supplementation, with the calculated metabolizable energy and the methionine level maintained as constants. A total of 360 hens were used in the experiment, which lasted 17 weeks. There was no apparent beneficial effect from blood meal supplementation and no significant difference statistically between protein levels.

At the end of the 17 weeks, the groups were reassigned to five basic treatments in which only the 16% protein level was continued and a sixth treatment which consisted of a standard corn-soy diet; this phase lasted an additional six weeks. Though egg production was slightly inferior for the garbanzo diets, the differences were not statistically significant. The cost of the feed ingredients required to produce one egg was higher for the garbanzo diets than for the corn diet. If by more efficient production of garbanzo its price is reduced and the feed efficiency is improved, garbanzo diets can probably be made more economical than corn-soy diets.

An observation made in 1960 revealed that the pancreas of chicks fed on garbanzo diets became greatly enlarged. It was reasoned that this phenomenon played some part in the inability of chicks to grow properly on high-level garbanzo diets. Additional data show that laying hens receiving garbanzo also suffer pancreatic hypertrophy, which is

Checking the effects of diet on skin pigmentation of broilers.

further aggravated by methionine supplementation. The significance of these findings is not understood at present.

It has been observed that the incidence of blood spots is consistently higher in eggs from laying hens in cages than in eggs from similar hens maintained in floor pens and especially under high temperature conditions. Adding reserpine to the diets of laying hens in cages or on floors has failed to reduce the incidence of blood spots.

Continuing studies on the evaluation of barley varieties grown in Mexico indicate that the addition of enzyme preparations as an integral part of the diet improves growth and feed efficiency as compared with nontreated barleys. The two enzymes used were commercial preparations donated by Dawe's Chemical Company and Nopco Chemical Company. Although at four weeks the chicks fed on barley diets weighed considerably less than those fed on corn diets, the improvement of the barley diets by enzyme supplementation was highly significant. It was also observed that the different barleys did not respond equally to the two enzymes in terms of chick growth and feed conversion.

Flower Petals as a Natural Pigmenting Agent

One of the most difficult problems which the feed manufacturer faces in Mexico is that of producing poultry feeds which give adequate yellow pigmentation to egg yolks and the skin (shanks, feet, beak, and skin fat) of poultry. The most common natural sources of pigment for poultry diets are yellow corn and alfalfa. Not only is corn a prime food for human consumption in Mexico but the production of yellow corn is very low. The amount of alfalfa which can be included in poultry feeds without noticeably altering feed efficiency is limited. A further problem is that the total amount of pigment consumed in modern rations has been reduced because of more efficient diets.

A good pigment source, then, would permit the utilization of grains poor in pigment without changing feed efficiency or affecting cost appreciably. In Mexico this implies that poultry feeds could be made using sorghums (poor in pigment), which would relieve the pressure of demand on corn.

After many materials of plant origin had been considered and discarded as possible sources of xanthophyll, attention was drawn to the Aztec marigold, *Tagetes erecta*. In Mexico, this flower is used to commemorate All Souls Day and is called *Zempasuchil*. The term "Zempa meal" has therefore been applied to the meal derived from its petals. The petals of the flower are dried in a forced draft of warm air, ground to a fine powder, and mixed directly into the poultry rations. Chemical analysis has indicated that Zempa meal contains 580 and 42 times as much xanthophyll (expressed in terms of beta-carotene) per gram as do yellow corn and alfalfa meal, respectively.

When used as the only source of xanthophyll in the diet of broilers and laying hens, Zempa meal imparts the desired intensity of yellow color, equaling alfalfa meal and surpassing yellow corn in effectiveness.

At the levels employed in these experiments, no deleterious effects have been observed on chick growth, feed efficiency, or egg production. It has also been found that the dietary xanthophyll level required to give good skin pigmentation or egg yolk color, as provided by Zempa meal, agrees closely with the recommendations in the literature. Furthermore, preliminary cost studies indicate that Zempa meal may be the most economical source of xanthophyll now available on the market.

INVESTIGATIONS WITH TURKEYS

In the plateau region of central Mexico, ladino clover is well adapted to the soil and climatic conditions of the higher valleys. The cool temperatures are also favorable for turkey production. With proper diet formulation, turkeys can be made to consume large quantities of clover (up to 1,250 grams per day) with a minimum of feed supplement. In a follow-up study of range rearing of turkeys on simplified diets, it was observed that a simple corn, salt, and mineral mixture gave the most economical gains up to 24 weeks of age.

It was further observed that breeding hens and toms reared on pasture and receiving in addition simplified supplementary diets, produced greater numbers of progeny than those grown in confinement on complete diets. These observations have been extended to the current breeding season, not only because the system of range rearing is simple and economical but also because it is believed that the physical condition of the breeding stock results in better reproductive performance.

In tests for Newcastle disease vaccine efficacy chickens a
ficially exposed to the disease are kept in isolation hou

Animal Pathology

Studies in animal pathology continue to emphasize poultry disease research and diagnosis. Research in bovine pathology, which began last year with bovine mastitis, has been extended to a study of the nature of reproductive problems in dairy cattle.

Avian Pathology

The progressive and rapidly developing poultry industry in Mexico has continued to demand close attention to its related disease problems. The poultry diagnostic laboratory and newly established microbiological research laboratory, located at the Veterinary School of the National University of Mexico, have been the principal centers of activity in this field.

DIAGNOSTIC LABORATORY

During the year covered by this report there has been a 25% increase in the number of cases submitted by regional poultrymen to the laboratory for diagnosis.

The ever-troublesome Newcastle disease and the complex syndrome known as "air-sac infection" have accounted, in equal proportion, for nearly 45% of all cases entering the laboratory during the year. An enzootic outbreak of laryngotracheitis, first reported by the laboratory last year, accounted for 7% of all cases diagnosed. Also worthy of mention is the recovery of three different isolates of a chick-embryo-stunting viral agent, later identified in the microbiology laboratory as infectious bronchitis virus.

MICROBIOLOGICAL RESEARCH LABORATORY

This laboratory, established early in the year with the assistance of a Rockefeller Foundation grant to the Veterinary School of the National University of Mexico, has made steady progress in research on infectious diseases of poultry.

The most noteworthy advances in this respect are: (1) the approval, through field testing, of an effective killed Newcastle disease vaccine; (2) preliminary acceptance through laboratory testing of a modified live-virus tissue culture vaccine against Newcastle disease; (3) the typification of 33 laryngotracheitis virus isolates from the recent enzootic of this disease; (4) the identification of infectious bronchitis virus; and (5) the verification of the widespread existence of infectious bronchitis throughout Mexico.

Newcastle disease of chickens continues to be a serious problem in Mexico but significant advances in our knowledge through research efforts hold much hope that the resolution of this problem will be forthcoming.

Research conducted in 1960 led to a strong suspicion that the highly pathogenic field virus prevalent in Mexico was immunologically quite divergent from the virus used in commercial vaccines. This view has gained support from preliminary laboratory tests performed by Dr. B. B. Hanson and co-workers at the University of Wisconsin. Further studies by this group are in progress and will be reported at a later date.

A killed-virus vaccine produced in our laboratory last year showed promise as an effective vaccine against Newcastle disease under simulated field conditions. This vaccine was released this year for limited experimental use under actual field conditions either as the only vaccine in use or in comparison with live-virus vaccine of the B_1 strain. The experimental vaccine gave acceptable protection in all cases. On one farm where Newcastle disease occurred, the chicks vaccinated with B_1 vaccine had a 45% mortality as compared with a 7% mortality in those vaccinated with the experimental vaccine.

Certain economical and practical factors make it more advantageous to use a live-virus vaccine than a dead-virus vaccine. An opportunity presented itself this year to test a new experimental live-virus strain vaccine produced in tissue culture in Belgium. The standard procedure used in our laboratory for vaccine testing under simulated field conditions, with artificial exposure to the pathogenic Mexican field strain, gave excellent results. The new vaccine protected 100% of the vaccinated birds, and 90% of the unvaccinated control birds died. Studies on this vaccine and its application in Mexico will be continued.

Laryngotracheitis research was largely limited to identification and typification of suspected virus material. A great deal of variation was encountered with respect to the pathogenicity of the various isolates when inoculated into susceptible birds. This factor is being studied further in the hope of resolving some of the problems encountered in the diagnosis of this disease. It is believed that the success or failure of control and eradication programs initiated by the Mexican government depends upon a better understanding of the characteristics of these virus isolates.

Infectious bronchitis of chickens has been considered by many persons to be a serious problem in Mexico but until very recently the geographic spread of this disease was unknown. Viral agents which caused a characteristic "embryo stunting" effect had been isolated in the past, and on three occasions this year, but these suspected isolates had not been identified positively in accordance with the established criteria of poultry disease specialists.

Now, however, in standard serum neutralization tests conducted in the poultry disease research laboratory, specific positive serum produced in the United States by the inoculation of susceptible chickens with infectious bronchitis virus has been shown to protect against the "embryo-stunting" effect of the virus isolates from Mexico.

The widespread incidence of this disease in Mexico has been verified through a survey of significant numbers of blood serum samples from the large poultry-producing areas. All regions surveyed showed a high incidence of serum neutralizing antibodies against infectious bronchitis virus. An average of 83% of the farms tested showed evidence of exposure to this virus.

The results of this survey strongly suggest that the relatively high incidence of "air-sac infection" is due to the fact that infectious bronchitis virus is a common trigger-factor or initiating cause of this syndrome. Current studies will attempt to elucidate this interrelationship.

BOVINE PATHOLOGY

Research relating to the bovine species has been limited to dairy cattle in general. The large milk-shed surrounding Mexico City has readily provided the location and material for study.

DAIRY CATTLE MASTITIS

The project in mastitis, which began over a year ago, has yielded some valuable information on the extent to which this disease affects milk production and on the consequent value of control programs on dairy farms in Mexico.

Nine months of milk production records from a typical Mexican dairy farm of approximately 200 cows were compared with the mastitis incidence when a mastitis control program was practiced in one half the herd and the other half served as the control.

During the sixth month of an intensive control program based on the diagnosis and treatment of *Streptococcus agalactiae* mastitis, a 5.2% increase in milk production resulted from a 35.5% decrease in the incidence of *S. agalactiae* mastitis.

Studies are now under way to modify the control program in such a manner that it might be better adapted to Mexican dairying conditions, which are characterized by large herds milked by hand.

REPRODUCTIVE PROBLEMS IN DAIRY COWS

Studies were initiated during the year on a long-term program aimed at determining the nature and severity of the complex of factors which affect the reproductive efficiency of dairy cattle.

The methodology involves routine rectal examinations of the breeding cows at 30-day intervals to determine the pregnancy status, pathology if any, and the cyclic activity of the ovaries.

Aberdeen Angus heifers in nutrition trial at Guadalajara.

Animal Nutrition

Growth of the animal industry in Mexico is essential to the realization of the maximum utilization of available nutrient sources. Many nutrient materials that are unfit for human consumption, such as roughages and industrial by-products, are suitable for animals and can be converted into high-quality animal foods. Also, current production of some plant materials surpasses the immediate dietary needs of the populace, and therefore these excesses are now available for utilization by livestock. Consequently the nutritional status of the populace can be improved through increased production of meat and milk by using these existing nutrient sources.

Much of the work done since the initiation of the research program in animal nutrition has been conducted with private institutions and individuals and with the Bank of Mexico.

In addition to the research investigations, two members of the program have accepted part-time teaching responsibilities. Ing. Marcial Velasco is teaching a course in animal nutrition at the University of Chihuahua. Dr. Raun is presenting a course in animal nutrition at the National School of Agriculture, Chapingo, and a course in ruminant nutrition at the Veterinary School of the National University.

CATTLE FEEDLOT STUDIES

Two cattle feedlot trials have been completed in cooperation with an oilseed extraction company in Guadalajara. They have supplied the animals, nutrients, and facilities while the animal nutrition staff of INIA have provided technical direction. The purpose of these trials was to determine the comparative value of safflower meal and cottonseed meal as protein sources for beef cattle. Safflower meal has not been widely accepted in Mexico as a supplementary protein source for ruminants.

In the first trial, using 18 Aberdeen Angus heifers that were fed fattening type diets, safflower meal and cottonseed meal were shown to have equal value on a protein equivalent basis.

TABLE 1.

Comparative feedlot performance of fattening heifers in feedlot receiving varying percentages of roughage materials in the diet.[a]

	Group			
	1	2	3	4
% Roughage in diet	37	39	47	51
Av. daily weight gain/ head (g.)	960	1012	848	962
Feed conversion	16.3	16.1	12.1	10.7
Cost/kg. gain (pesos)	8.32	7.58	7.04	5.72
Profit/animal (pesos)[b]	46	121	176	214

[a] Trial lasted 100 days; 10 animals/group.

[b] Based on original value of 4.00 pesos/kg. at the beginning of the trial for all animals. Selling price for groups 1 and 2 was 5.00 pesos/kg. and for groups 3 and 4, 4.80 pesos/kg.

In the second trial at Guadalajara, a mixture of safflower meal and urea was compared with cottonseed meal as a protein source in rations containing cottonseed hulls, molasses, and corn silage. These ration ingredients represent nutrient sources that are locally available and are economically feasible to use. In addition, safflower meal, urea, molasses, and cottonseed hulls are nutrient sources that lend themselves to incorporation in cattle diets but either are not being fully utilized or are largely wasted. Whereas 18 Aberdeen Angus heifers were used in the first trial, 40 common native bulls were used in this second trial. Half the animals were implanted with stilbestrol. The safflower meal-urea supplementary protein source was shown to be completely equal to cottonseed meal. No response was obtained from stilbestrol implantation.

A third trial, in cooperation with the same oilseed extraction company, is now in progress. Experimental design and treatments are the same as in the second trial, except that fresh chopped sugar cane has been substituted for corn silage and higher stilbestrol implantation levels are used.

Experimental cattle feedlot facilities have been constructed at Cotaxtla with funds supplied by the Bank of Mexico, and technical guidance and assistance in both the design and construction of these facilities and the conduct of the experiment were provided by the animal nutrition staff. The primary purposes of this type of experimentation are, first, to investigate and demonstrate the nutritional value of nutrient materials that are locally available at economically feasible prices, and second, to demonstrate methods of producing more beef in a shorter period of time under confinement cattle feeding conditions. A trial using 60 Zebu-Brown Swiss crossbred steers is now under way in these facilities. Molasses-urea type protein supplements are being compared with cottonseed meal as protein sources in diets containing molasses, corn cobs, rice polishings, and corn silage.

A feedlot trial to observe growth performance with varied dietary energy levels was conducted cooperatively with a rancher near La Campana who provided feeder heifers, feedlot facilities, and nutrients. Results of this trial are given in Table 1. These data illustrate the economic superiority of the lower energy diets under Mexican market conditions.

RANGE NUTRITIONAL STUDIES

Expanded studies in animal nutrition and management are now under way at La Campana. Increasing calving percentages and calf weaning weights as well as supplying the type of animals that best meet market demands are of prime economic consideration in this range area. These goals can be achieved only by using improved practices in animal nutrition and breeding, and at the same time utilizing correct range management and conservation practices. The purchase of 60 Hereford heifers last fall represents the institution of cow-calf research at this station.

Investigations of the effects of protein, phosphorus, and trace mineral supplementation on winter range are in progress. While the primary purpose of the protein and mineral supplementation is to observe effects on growth performance, the trace mineral supplementation is included to study a possible interrelation between selective grazing of the native toxic plant alfombrilla and a dietary trace mineral deficiency. As the alfombrilla content of most minerals is very high, it is possible that this plant is selectively grazed by animals seeking to satisfy a dietary trace mineral deficiency. The effect of stilbestrol implantation on growth performance of these heifers under range conditions will be observed this summer.

In a cooperative trial a rancher supplied yearling heifers which were implanted with stilbestrol while on winter range. Though digestible energy and protein intake were low, a small response was obtained as a consequence of stilbestrol implantation.

Discussing a farm management study at a CIANO field day.

Agricultural Economics

During the past year the Mexican economy has experienced one of its most serious periods of recession in the postwar period. Real growth in gross national product has been estimated at approximately 3%, which is about the same as the percentage increase in population. The failure of the economy to make real per capita progress called attention to the continuing economic problems of the great majority of the rural population, the group in Mexico in which there is the most serious concentration of poverty. Poverty in agriculture represents a dual limitation to the development of the general economy, namely, the sector's excessively small contribution of products and its consequent failure to constitute an effective market for industrial products. The increased awareness of this dual limitation is leading to the formulation of more effective public programs to increase the productivity and income levels of rural people. The work which the agricultural economics program has under way in farm production economics, in both the private and *ejidal* sectors, promises to provide useful information in the formulation of these public programs.

Because of the many administrative problems related to the reorganization of Mexico's agricultural research institutions very little new work was undertaken during the past year. The program has used the time to consolidate the work of previous years and has at the same time cooperated with the Department of Agricultural Economics at the National School of Agriculture. At present program staff are teaching the classes of farm management and research methods in agricultural economics. At the request of the Mexican Ministry of Agriculture, the staff are also teaching farm management in a seven-month International Agricultural Credit Course, jointly sponsored by the Organization of American States and the Ministry.

TABLE 1.

Description of average farm structure for farms under private proprietorship. Yaqui Valley, Sonora.

Concept	Quantity
Crop land (hectares)	136
Labor employed (man-years)	10
Capital investment excluding value of land (pesos)	288,600
Farm income (pesos)	135,800

EVALUATING MANAGEMENT OF INDIVIDUAL FARMS

One of the fundamental objects of the field studies has been to provide knowledge that will help those who have control over resources to use them more effectively. Data from a farm survey carried out in the Yaqui Valley have been analyzed in an attempt to identify those factors which determine farm earnings and which are under the control of the farmer. The area is one of commercial type farming, as indicated by the data in Table 1, having relatively large farms with full complements of labor supply and capital goods.

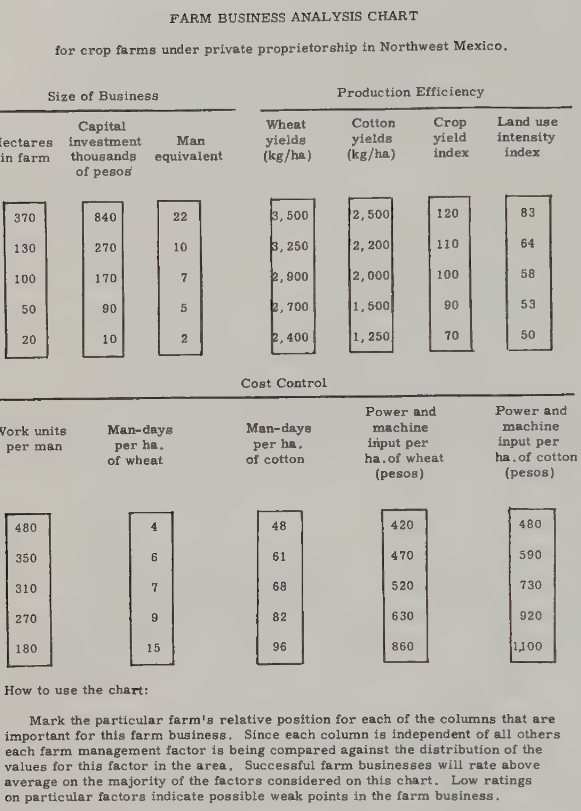
The data presented are averages and it should be appreciated that there is a great deal of variability within the area with respect to farm size, effectiveness of production processes, and farm income. It is known, for example, that some farms produced incomes of over 500,000 pesos, while during the same crop year others had losses of more than 50,000 pesos. Data from the farm survey of the Yaqui Valley were analyzed by cross-tabular procedures to evaluate those factors which influence farm earning. The analyses verified that in this area, as in many other areas of the world, higher farm earnings are positively correlated with each of the following management factors: larger-sized farm businesses, higher than average crop yields, higher than average physical productivity per worker, more intense utilization of available land, and lower than average power and machinery costs. There is also an accumulative effect of these farm management factors which was evaluated by classifying the farms according to the number of factors on which the particular farm rated above the regional average. Those farms which rated above average on all factors had average incomes of more than 500,000 pesos, while those which rated below average on all factors had practically zero incomes. It is interesting to note that not one farm which was below average on all factors had a positive return to the farmer for either his labor and management effort or for his capital investment.

These relationships between the farm management factors and farm earnings enable the development of a scheme for evaluating the management of particular farms. The critical management factors which are under the control of the farmer may be included on a farm business analysis chart. The distribution of the values for these factors in the area considered may be given by quintiles, as shown in Figure 1. The farmer may then mark his relative position compared with other farmers in the region and have an objective method for evaluating the management of his farm business even if he keeps only the most rudimentary accounts. The analysis chart should point out to him those areas of his farm business which need to be studied most carefully to obtain higher levels of income.

A preliminary version of this farm business analysis chart was evaluated in the field. Farmers, extension agents, and agricultural credit managers indicated interest in having the chart available for evaluating the effectiveness of the management of farm businesses in the area.

COLLECTIVE EJIDAL FARMS IN THE YAQUI VALLEY

When the agrarian reform program was carried out in the Yaqui Valley of Sonora it



FARM BUSINESS ANALYSIS CHART

for crop farms under private proprietorship in Northwest Mexico.

Size of Business			Production Efficiency			
ectares in farm	Capital investment thousands of pesos	Man equivalent	Wheat yields (kg/ha)	Cotton yields (kg/ha)	Crop yield index	Land use intensity index
370	840	22	3,500	2,500	120	83
130	270	10	3,250	2,200	110	64
100	170	7	2,900	2,000	100	58
50	90	5	2,700	1,500	90	53
20	10	2	2,400	1,250	70	50

Cost Control

ork units per man	Man-days per ha. of wheat	Man-days per ha. of cotton	Power and machine input per ha. of wheat (pesos)	Power and machine input per ha. of cotton (pesos)
480	4	48	420	480
350	6	61	470	590
310	7	68	520	730
270	9	82	630	920
180	15	96	860	1,100

How to use the chart:

Mark the particular farm's relative position for each of the columns that are important for this farm business. Since each column is independent of all others each farm management factor is being compared against the distribution of the values for this factor in the area. Successful farm businesses will rate above average on the majority of the factors considered on this chart. Low ratings on particular factors indicate possible weak points in the farm business.

Figure 1. Farm business analysis chart.

was decided by the Agrarian Department that all of the *ejidal* farms would be organized on a cooperative farming basis. Although from the beginning there was some discontent among members because of this type of organization, all of the farms remained nominally as collective operations until about 1952. At that time the Agrarian Department and the Ejido Bank allowed the *ejidatarios* to decide whether they would prefer to continue in collective societies or would prefer to have the land divided into parcels with individual operation.

In the majority of the *ejidos* in the Valley the members decided to divide into two groups, one continuing with collective operation and the other organizing itself on an individual basis. The process of dissolution of collective farms into individual parcels has continued up to the present time. Recently it was calculated that only 15% of the *ejidatarios* remain in 14 collective societies and that of these 14 societies perhaps only one is a truly collective farming operation. In each of the other 13 societies there are some aspects of individual exploitation.

The collective farms in the Yaqui Valley have an average of 32 members and possess 676 hectares of irrigated land, which gives them an average of 21 hectares per member. The capital investment is slightly more than 500,000 pesos, indicating an average of about 16,000 pesos of capital per *ejidatario*. These capital and land endowments per member of collective societies are quite similar to the relationships encountered among *ejidatarios* operating their parcels individually. Wheat and cotton were the only crops planted by the collective societies and there were no livestock enterprises on these farms. Wheat yields were approximately the same as those generally obtained in the Valley while the cotton yield was below the area average for the year under consideration.

The farm income averaged about 344,000 pesos, which may be considered the value of product resulting from the land, capital, and management inputs. If a differential rent charge is made for the use of the land and an interest charge is made for the use of capital, the total imputed charge, which may be considered the opportunity cost for the use of these resources, is more than 100,000 pesos greater than the return earned by these resources on the collective farms. The owners of these resources could have obtained considerably more income by renting the resources to others rather than by managing them themselves; this is indicative of serious faults in the organization and management of these farms. It should be pointed out that members of the society were provided employment by the farm business, since this is a cooperative enterprise. The societies also hired non-members as workers, and unfortunately the accounting system did not identify the wage payments to members as contrasted with non-members. It was possible, however, to identify from supplementary records the work contribution of members as contrasted with non-members for several of the societies. In those societies for which information was available the members worked only about 100 days per year while more than half the work was done by hired workers. Because of the extreme seasonality of some farm work, such as the picking of cotton, it is to be expected that some hired labor will be used on these farms. Nevertheless, there was considerable opportunity for greater member participation in the physical labor on these farms.

There is one other aspect of labor-use on these farms, and that is the tendency to use too much labor in the production processes. On those farms for which data were available the collective *ejidal* farms used approximately 50% more labor per ton of product than did private farms in the same area using similar production practices. This appears to have been in part the result of giving members easy supervisory jobs which may not have been productive.

The original study of these collective farms depended on global accounting data provided by the Ejidal Bank serving this zone. These data are exact and adequate for the purpose of the bank, but fail to provide the necessary details related to the internal operation of the societies for the purpose of detailed economic analysis and good farm management. We are at present reformulating a phase of this study which will consider in detail the internal arrangements currently being used to aid or impede member incentives, arrangements for the distribution of profits, individual member standards of living, alternative cropping and livestock systems, alternative systems of society organization, and adequate accounting systems for the management of collective farms. These factors which treat the organization of individual societies will in turn be considered in terms of the institutional parameters which limit the forms of *ejidal* organization in the area.

Farmers registering at a field day.

Agricultural Information

The agricultural information program has three principal aspects: the diffusion of research results in the form of technical reports for scientists and recommendations for farmers, in-service training of specialists in information methods, and research related to information methods and the factors which would improve the acceptance of improved farming practices.

During the first full year of operation of INIA the information program has taken an important part in introducing the concept that a research project is not completed until the results have been made known to farmers and professionals—research workers, educators, and extensionists—systematically and rapidly by the most adequate channels. The provision of these channels has obviously served as a stimulus to many research workers at the outlying stations who are now better able to appreciate the substantial social value of their research activities.

Close cooperation has been continued with the federal Extension Service, the State of México Extension Service, and many other agencies working in agricultural development.

PUBLICATIONS

RESEARCH REPORTS

The twelfth number of *Agricultura Técnica en México* contained a total of 19 articles summarizing the principal research results obtained at INIA experiment stations. Because of the increasing demand for this journal, on the part of both Mexican and foreign agronomists, the edition has been enlarged from 6,000 to 7,000 copies.

Two extensive reports were published during the year, one covering the 1959-1960 period of work of the Office of Special Studies and the other the proceedings of the seventh annual meeting of the Central American Corn Improvement Project, which was held in Tegucigalpa, Honduras, February 20–23, 1961.

BULLETINS FOR FARMERS

Continued cooperation was given to the federal Extension Service in the editing and illustrating of bulletins for the Extension series. These bulletins offer concrete recommendations on improved varieties and cultural practices for different areas of Mexico, and are brought up to date each year when the results of research have been analyzed. This year 15 of these bulletins were re-edited and about 150,000 copies were printed and distributed. The distribution is carried out by extension agents, through field days, and through mail distribution in answer to requests for information on specific crops.

The quarterly bulletin *Novedades Hortícolas*, prepared by the horticulture program of INIA, completed its sixth year of regular publication. Fourteen articles of special interest to the steadily increasing group of vegetable farmers appeared during the year.

In order to promote the planting of home gardens, the horticulture program also prepared a calendar including the important dates for planting, insect and disease control, harvesting, etc. This was attractively illustrated and later published by the federal Extension Service.

The regional circular series have been continued and new series have been added for the new regional centers. Each series will include all the farmer bulletins from the experiment stations in the region. During the past year seven new regional circulars were printed and five were reprinted.

DISTRIBUTION

The distribution policy of INIA is a relatively conservative one in that publications are not distributed in quantities at agricultural fairs and other events. At field days, a supply of all the bulletins which contain recommendations applicable in the region are made available but farmers are asked to indicate the subjects in which they have a special interest.

The technical publications and a small number of farmer publications are distributed to a rather select mailing list of some 3,000 addresses including scientists, research institutions, specialized libraries, extension agents, teachers, editors, and farmers in Mexico and 55 other countries.

INFORMATION REQUESTS

The farmer publications are also very helpful in answering a large number of written requests for information on specific problems. A total of 873 requests were answered during the year, of which 618 came from Mexico, 193 from other countries of Latin America, 28 from the United States, 21 from Europe, 6 from Asia, 4 from Africa, and 3 from Oceania.

In addition, 280 requests on a wide variety of questions related to tropical agriculture were handled by the information section at Cotaxtla.

PRESS, RADIO, AND TELEVISION

The value of the technical information published by INIA is well recognized by the national and regional press as well as the farm press, radio, and television networks. Numerous requests for information are received each month from editors in charge of farm sections, and each request has been given personal attention. As a consequence, most of the leading farm magazines and agricultural pages in newspapers carry at least one article based on INIA recommendations each month, thereby multiplying the distribution of each farmer bulletin. In this sense the regional circulars have been especially well received.

Up to now, the regional press has been used systematically only in the case of the popular farm page in *El Dictámen* of Veracruz, which will complete five years of weekly publication in August, 1962. However, a vast number of local newspapers as well and radio and television stations have given wholehearted cooperation in publicizing the field days and other special events at the regional experiment stations.

In the radio field, plans are under way for a series of interviews with INIA research staff for the *La Hora del Rancho Alegre* program, which is transmitted on a network of 70 local stations.

FIELD DAYS

During the past year, field days were held at eight of the INIA experiment stations. More than 7,000 farmers and cattlemen attended, as can be seen in the following table:

Place	Field day for:	Date	Attendance
Cd. Delicias	Farmers	Aug. 8, 1961	839
La Campana	Cattlemen	Aug. 10, 1961	700
Torreón	Farmers	Aug. 12, 1961	250
El Horno	Farmers	Sept. 23, 1961	625
Cotaxtla	Farmers & Cattlemen	Oct. 20, 1961	1,500
Zacatepec	Farmers	Nov. 14, 1961	475
CIANO	Farmers	Apr. 4, 1962	2,045
El Roque	Farmers	Apr. 26, 1962	882

In addition, two special demonstrations were held for small groups, one on rubber at El Palmar, Veracruz, and one on cacao at Rosario Izapa, Chiapas.

In spite of the fact that these were the first field days ever held at the Zacatepec, Torreón, Ciudad Delicias, El Palmar, El Roque, and Rosario Izapa stations, there were large numbers of farmers in attendance. At the other stations the attendance continued to move up, resulting, in the case of CIANO, in the largest experiment station field day ever held in Mexico.

As the stations have gained prestige and farmers have gained confidence in attending, there have been an increasing number of farmers with very small parcels and *ejidatarios* at the field days. This is true for all stations, but especially at Cotaxtla where 66.8% of the farmers attending this year were *ejidatarios*.

AGRICULTURAL FAIRS

During the year exhibitions were presented at 11 fairs held in the States of Baja California, Tabasco, Coahuila, México, Veracruz, Yucatán, Guerrero, Aguascalientes, and Puebla. In several cases an artist took charge of planning, preparing the illustrative material, and mounting the exhibition. When this was not possible, collections of bulletins were sent for exhibit with a sign inviting farmers to write directly to INIA for the information which interested them. A large exposition was also mounted at the experiment station at Tapachula, Chiapas, for a presidential visit.

PHOTOGRAPHIC LABORATORY

The information program depends on high-quality photographs to illustrate many of the concepts presented in INIA publications, and the laboratory is thus one of the mainstays of the program.

In addition to being used in all INIA publications, these photographs are reprinted widely by farm magazines, such as *Tierra*, *El Campo*, *El Surco*, *Hacienda*, and *Agricultura de las Américas*. Enlargements also provide much of the illustrative material used in exhibitions at agricultural fairs.

The photographic laboratory also serves the Inter-American Food Crop Program and has provided advice and dark-room plans for the International Rice Research Institute and the Colombian and Chilean Agricultural Programs.

AGRICULTURAL FILMS

Sixteen films—14 in color and 2 in black and white—have been completed to date. These have all been produced in the educational 16 mm size, with narrations in Spanish on optical sound tracks. According to the latest count, 239 copies of these films have been distributed. They are being used constantly by many educational agencies—Mexican as well as foreign, governmental, and private. They have been projected in all of Mexico's 29 states and 2 territories and are currently being used in at least 6 other countries of Latin America. The titles of these films and the number of copies purchased of each up to April 30, 1962, are listed below.

Title	No. of copies
Proteja su cosecha (Protect your harvest)	17
El huerto familiar (The home garden)	29
El cultivo del frijol (The cultivation of beans)	20
Así como siembres cosecharás (As you plant, so shall you reap—reasons for seed testing)	12
La cría de pollitos (Giving chicks a good start)	24
Abone su maíz y coseche más (Fertilize your corn and harvest more)	22
Buscando una agricultura mejor (Searching for a better agriculture)	14
Alfalfa, la reina forrajera; siembra (Alfalfa, the queen of forages: establishing a good stand)	15
Un ganadero, su rancho y zacate Merkerón (A cattleman, his ranch, and Merkerón grass)	13
El mejoramiento del hogar rural (The improvement of the rural home)	6
Manejo y utilización de la alfalfa (Management and use of alfalfa)	10
La ciencia agrícola impulsa al Noroeste (Agricultural science stimulates the Northwest)	15
El camote, la raíz de oro (The sweet potato, root of gold)	3
Tarétaru (A story of a farm family that benefits from planting disease-resistant potato varieties)	14
Forraje ensilado: alimento seguro en la epoca seca (Grass silage: a sure source of feed during the dry season)	13
La herencia del ganadero (The heritage of the cattleman)	12
Total	239

In Mexico, the agency which has made the greatest use of these films is the federal Extension Service, which has also participated in producing many of them. The Extension Service has eight mobile units, but not all could be in operation during the past year. The result was a slight reduction from last year in the number of persons who saw the films. This decrease was counterbalanced, however, by a greater number of projections made with copies loaned by INIA to agencies having their own projector. In this way the films reached nearly 130,000 farmers, apart from the projections in other countries for which there are no data available.

Interviewing Bajío farmers in a study on acceptance of new agricultural practices.

Art Work

The art section handled a total of 914 jobs during the year. These included the designing and illustrating of all the publications mentioned earlier in this report, preparation of exhibits, and the designing of more than a dozen silk screen posters for publicizing farm field days and promoting improved practices. In addition, a large number of graphs, charts, maps, signs, and drawings were made.

Dissemination of Information From the Regional Centers

The information program started at Cotaxtla five years ago has succeeded so well that it is planned to establish a similar program at each of the other regional centers in order to disseminate recommendations for local application based on local research. An information specialist has been assigned to CIANO since February, 1962, and at El Roque in the Bajío a bench-mark study has been completed preparatory to initiating an information program there.

RESEARCH ON INFORMATION METHODS

This research program has been set up to study the factors which limit the rapid acceptance of improved farming practices. This includes mapping, geographically and by socio-economic groups, of the audiences which are currently reached by the various communications media, as well as studies of the effectiveness of these media in carrying different messages to distinct audiences. It also includes intensive studies with farm families to determine the process by which different practices are accepted or rejected.

During the past year the following studies have been completed:

(1) An evaluation of the journal *Agricultura Técnica en México* as a medium for communication of scientific information to a professional audience.

(2) A survey of the information media available in northwest Mexico and a study of their use by farmers of the Yaqui Valley.

(3) A delineation of procedures involved in the planning and production of educational films for rural audiences.

During the year, data were collected in the Bajío area for a fourth study which has as its objective determination of the influence of different information sources on the acceptance of certain improved farming practices.

The long-term study of a development program in an *ejido* in the tropical area of Veracruz is now in its fourth year. Records are being kept of all outside influences as well as the changes which occur within the *ejido*. Up to now this study has provided some important insights into the possibilities of change and the rapidity with which changes can be introduced into a community of this type.

Library, Cotaxtla.

Library

THE COLLECTION

The present holdings of the library include 13,602 bound volumes, of which 7,420 are books and 6,182 are scientific serials. The central library in Mexico City contains 11,386 volumes, while the branch libraries at Cotaxtla and CIANO have 1,038 and 1,178 volumes, respectively.

The above material has been enriched with two sets of fourteen complete collections of different titles of serials which were arriving at the time of writing this report and will be added to the central library and Cotaxtla. New subscriptions to journals have been added in all three libraries. The United States Atomic Energy Commission has just donated to the central library a complete collection of *Nuclear Science Abstracts*, which contains information regarding the use of radioisotopes in biology and agricultural sciences.

TECHNICAL SERVICES

As in the past, the policy of the library has been to centralize the technical processes related to selection, acquisition, and cataloguing of the materials for distribution to Cotaxtla and CIANO. A total of 1,735 new books were purchased and classified; of this group 635 were added to the central library, 561 were sent to Cotaxtla and 539 to CIANO. Other materials were organized, such as U.S. Department of Agriculture publications, bulletins of U.S. agricultural experiment stations, and reprints and periodicals from other parts of the world which are received on an exchange or donation basis.

Many INIA stations are now receiving different kinds of material from the central library, and it is planned to open library branches at additional regional centers as soon as adequate facilities are available. In the meantime, boxes containing 100 books each are being sent to the stations on a loan basis for a month.

USE OF THE LIBRARY

The following statistics have been compiled on use of the library during the year:

Books taken out	799
Books used in the library	2,832
Periodicals taken out	337
Periodicals used in the library	4,981
Reprints taken out	115
Reprints used in the library	872
Miscellaneous publications taken out	212
Miscellaneous publications used in the library	1,825
Consultations	468
Attendance	5,678

REFERENCE DEPARTMENT

The library continues to supply scientific materials, bibliographic tools, and all kinds of information related to agricultural sciences to INIA staff members wherever they are located, to the different official and decentralized institutions in Mexico City, and to institutions of higher education in the interior of the country.

This year the library was particularly pleased to have the opportunity to assist the Universities of Guerrero, Guanajuato, and Coahuila and the Technological Institute of Monterrey and Oaxaca in establishing or reorganizing their libraries and research facilities.

The library maintains an active interlibrary loan service with the following American institutions: the University of Michigan, the U.S. Department of Agriculture, and the U.S. Library of Congress. The Graduate School at Chapingo has benefited greatly from this international loan service.

OTHER ACTIVITIES

The library participated actively in the Third Regional Workshop on Utilization of Nuclear Energy Information, held in Mexico City April 9-14, 1962. The part of the conferences involving librarians from Mexican and Central American universities and other institutions was held in the INIA library.

The library has been invited to participate in the preparation of a National Union List of Serials of Mexico which the U.S. National Science Foundation expects to finance through the Science Information Service of the Pan American Union. The National University of Mexico is sponsoring this project.

At the invitation of the National University of Mexico, the library is also participating in the planning of the new Documentation Center at the university.

In addition, the library has been invited by the Inter-American School of Library Science, Medellín, Colombia, to take part in the Agricultural Library Technical Reunion of Colombia, which will be held this summer.

On April 28 of this year the library was host to members of the Mexican Association of Librarians during one of their regular sessions.

Colombian Agricultural Program

Personnel

COLOMBIAN AGRICULTURAL PROGRAM

MINISTRY OF AGRICULTURE

His Excellency, **Dr. Hernán Toro Agudelo,** Minister of Agriculture
His Excellency, **Dr. Otto Morales Benitez,** Minister of Agriculture (to September, 1961)
Daniel Mesa Bernal, ING. AGR., Director General
Joaquín Vanin Tello, Secretary General
Hernando Lora M., VETERINARIAN, Head, Technical Section
Anibal Duque Vélez, Administrative Secretary

DIVISION OF AGRICULTURAL RESEARCH (DIVISION DE INVESTIGATIONES AGROPECUARIAS—"DIA")

Canuto Cardona A., PH.D., Director
Jacinto López H., ING. AGR., Acting Subdirector
Emigdio Pinzón M., VETERINARIAN, Subdirector
Milciades Martínez G., VETERINARIAN, Head, Publications Office
Jorge Pinzón, Administrator
Vicente Alba R., ING. AGR., Head, Coordination

EXPERIMENT STATIONS

Pedro María Contreras C., VETERINARIAN, Director, Armero Station
Luis Carlos Wiedemann T., VETERINARIAN, Director, El Nus Station, San José del Nus
Alfredo Usme R., VETERINARIAN, Director, La Libertad Station, Villavicencio
Alberto Mesa B., ING. AGR., Subdirector, La Selva Substation, Rionegro
Bernardo Salazar R., VETERINARIAN, Director, Montería and Turipaná Stations, Cereté
Orlando Sánchez E., ING. AGR., Director, Nataima Station, Espinal
Jaime Medina P., ING. AGR., Director, Obonuco Station, Pasto
Carlostadio Sánchez P., M.S., Director, Palmira Station, Palmira

José Joaquín Cortés C., VETERINARIAN, Director, San Jorge Station, Soacha
Alfredo Fernández M., ING. AGR., Director, Surbatá Station, Duitama
Alvaro Gartner N., M.S., Director, Tibaitatá Station, Bogotá
Jorge L. Suescun G., ING. AGR., Subdirector, Tibaitatá Station, Bogotá
Reynaldo Rubio R., VETERINARIAN, Director, Toluviejo Station, Toluviejo
Ernesto Arango U., ING. AGR., Director, Tulio Ospina Station, Medellín

OFFICE OF SPECIAL RESEARCH (OFICINA DE INVESTIGACIONES ESPECIALES—"OIE")

U. J. Grant, PH.D., Director OIE, The Rockefeller Foundation
Robert K. Waugh, PH.D., Assistant Director OIE, The Rockefeller Foundation

CORN IMPROVEMENT

Dale D. Harpstead, PH.D., Technical Director, Associate Geneticist, The Rockefeller Foundation
Efraín Díaz B., ING. AGR., Geneticist, Head, Palmira Station
Daniel Sarria V., ING. AGR., Geneticist, Palmira Station
Fernando Arboleda R., ING. AGR., Geneticist, Tibaitatá
Manuel Torregroza C., M.S., Geneticist, Head, Tibaitatá (on study leave)
Ricardo Ramírez E., M.S., Codirector, Tulio Ospina
Bertulfo Peña V., ING. AGR., Geneticist, Head, Tulio Ospina
Clímaco Cassalett D., M.S., Geneticist, Head, Turipaná (on study leave)
Javier Gómez J., ING. AGR., Geneticist, Turipaná

WHEAT IMPROVEMENT

John W. Gibler, PH.D., Technical Director, Plant Pathologist, The Rockefeller Foundation
Charles F. Krull, PH.D., Assistant Technical Director, Assistant Geneticist, The Rockefeller Foundation
Mario Zapata B., M.S., Subdirector, Tibaitatá (on study leave)
Rafael López O., ING. AGR., Geneticist, Head, Tibaitatá
Daniel Varela A., ING. AGR., Geneticist, Tibaitatá
Santiago Fonseca M., B.S., Auxiliary Geneticist, Tibaitatá (on study leave)
Luis A. Rojas M., ING. AGR., Auxiliary Geneticist, Tibaitatá (to April, 1962)
Antonio Miranda H., ING. AGR., Auxiliary Geneticist, Tibaitatá (to May, 1962)
Marco Cano L., ING. AGR., Auxiliary Geneticist, Tibaitatá (to November, 1961)
Hernando Reaga S., ING. AGR., Farinologist, Milling and Baking Laboratory, Tibaitatá
Diego Robledo R., ING. AGR., Agronomist (commissioned by Caja Agraria for regional trials in Cundinamarca)
Oscar Saldarriaga R., ING. AGR., Agronomist (commissioned by Caja Agraria for regional trials in Nariño)

BARLEY IMPROVEMENT

John W. Gibler, PH.D., Technical Director, Plant Pathologist, The Rockefeller Foundation

Charles F. Krull, PH.D., Assistant Technical Director, Assistant Geneticist, The Rockefeller Foundation

Luis A. García G., ING. AGR., Geneticist, Head, Obonuco

José A. Sierra F., M.S., Geneticist, Tibaitatá (part time, commissioned by Procebada)

Jens Otto Kornerup G., ING. AGR., Auxiliary Geneticist, Tibaitatá (part time, commissioned by Procebada)

Gabriel Robayo I., ING. AGR., Auxiliary Geneticist, Tibaitatá (commissioned by Procebada)

Gabriel Rico R., ING. AGR., Auxiliary Geneticist, Tibaitatá (commissioned by Procebada)

Jorge Adames B., ING. AGR., Auxiliary Geneticist, Tibaitatá (to December, 1961, commissioned by Procebada)

Eduardo Bernal G., ING. AGR., Auxiliary Geneticist, Tibaitatá (to August, 1961, commissioned by Procebada)

Rafael Contreras S., ING. AGR., Agronomist, Tibaitatá (commissioned by Procebada for regional trials)

OAT IMPROVEMENT

Charles F. Krull, PH.D., Technical Director, Assistant Geneticist, The Rockefeller Foundation

Reinaldo Reyes N., ING. AGR., Geneticist, Head, Tibaitatá (commissioned by Quaker Oats Company)

José A. Estévez C., ING. AGR., Auxiliary Geneticist, Tibaitatá (to June, 1961)

RICE IMPROVEMENT

Manuel Rosero M., M.S., Geneticist, in charge, Nataima

Fernando Estrada R., ING. AGR., Auxiliary Geneticist, Nataima

Oscar Sohm K., ING. AGR., Auxiliary Geneticist, Nataima (on study leave)

Joaquín González F., ING. AGR., Auxiliary Geneticist, Palmira Station (assigned by National Rice Federation)

BEAN IMPROVEMENT

Canuto Cardona A., PH.D., Acting Technical Director, Plant Pathologist, DIA

Luis H. Camacho M., M.S., Geneticist, Head, Palmira Station (on study leave)

Hugo Orozco S., ING. AGR., Auxiliary Geneticist, Palmira Station

Antonio Delgado G., ING. AGR., Auxiliary Geneticist, Palmira Station

Marco A. Castillo D., ING. AGR., Auxiliary Geneticist, Tibaitatá

Rodrigo Duarte T., M.S., Geneticist, Head, Tulio Ospina

Ivan Alvarez G., ING. AGR., Auxiliary Geneticist, Tulio Ospina

POTATO IMPROVEMENT

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Nelson Estrada Ramos, ING. AGR., Geneticist, Head, Tibaitatá (on study leave)
Lauro Luján Claure, ING. AGR., Auxiliary Geneticist, Tibaitatá (on study leave)
Edmundo Pérez Montenegro, ING. AGR., Auxiliary Geneticist, Tibaitatá
Luis A. Varon C., ING. AGR., Auxiliary Geneticist, Tibaitatá (assigned to Popayán)
Humberto Valencia A., ING. AGR., Auxiliary Geneticist, Tibaitatá

FORAGE AND PASTURE CROPS

Loy V. Crowder, PH.D., Technical Director, Agronomist, The Rockefeller Foundation
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Silvio Echeverri E., M.S., Agronomist, Tibaitatá (on study leave)
Hernán Chaverra G., ING. AGR., Auxiliary Agronomist, Tibaitatá (on study leave)
Guillermo Riveros R., ING. AGR., Auxiliary Agronomist, Tibaitatá
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Gustavo Herrera P., ING. AGR., Auxiliary Agronomist, Tulio Ospina
Libardo Escobar R., ING. AGR., Agronomist, Turipaná

SOIL SCIENCE

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PLANT PATHOLOGY

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Enrique Torres T., ING. AGR., Auxiliary Plant Pathologist, Acting Head, Palmira Station
Rodolfo Barriga O., ING. AGR., Auxiliary Plant Pathologist, Tibaitatá (on study leave)
Julia Guzmán N., PH.D., Plant Pathologist, Tibaitatá
Juan E. Orjuela N., PH.D., Plant Pathologist, Head, Tibaitatá
José J. Castaño A., M.S., Auxiliary Plant Pathologist, Acting Head, Tulio Ospina

ENTOMOLOGY

Robert F. Ruppel, PH.D., Technical Director, Entomologist, The Rockefeller Foundation (to March, 1962)
Gilberto Bravo V., ING. AGR., Entomologist, in charge, Obonuco
Eduardo Idrobo M., ING. AGR., Auxiliary Entomologist, Palmira Station
Alfredo Saldarriaga V., M.S., Entomologist, Head, Palmira Station
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Lázaro Posada O., M.S., Entomologist, Tibaitatá
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Jaime Vergara V., VETERINARIAN, Animal Husbandman, La Libertad
Omar Patiño H., VETERINARIAN, Animal Husbandman, Palmira Station
Carlos Van Cotthem M., B.S., Animal Nutritionist, Tibaitatá
Camilo Duque G., B.S., Animal Husbandman, Tibaitatá
Manuel Alvarez R., M.S., VETERINARIAN, Animal Physiologist, Tibaitatá
Oscar Cardona A., VETERINARIAN, Animal Husbandman, Turipaná (on study leave)
José J. Gutiérrez O., B.S., Animal Husbandman, Turipaná
Gustavo Hernández B., VETERINARIAN, Animal Husbandman, Turipaná
Horacio Ayala C., VETERINARIAN, Animal Husbandman, Turipaná

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Francisco Mario Botero L., VETERINARIAN, Dairy Husbandman, El Nus
José Jesús Franco, VETERINARIAN, Dairy Husbandman, Obonuco
Alfredo Serrano Q., VETERINARIAN, Dairy Husbandman, Palmira Station

Bernardino Rodríguez U., VETERINARIAN, Dairy Husbandman, Tibaitatá (to September, 1961)

Samuel Ramírez V., VETERINARIAN, Dairy Husbandman, Tibaitatá (to January, 1962)

Oswaldo Acosta J., VETERINARIAN, Dairy Husbandman, Tibaitatá

Guillermo Cedeño S., VETERINARIAN, Dairy Husbandman, Tibaitatá

Juan José Salazar C., VETERINARIAN, Dairy Husbandman, Tibaitatá

Ernesto Huertas V., VETERINARIAN, Dairy Husbandman, Tibaitatá

Jaime Rubio U., VETERINARIAN, Dairy Husbandman, Turipaná

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Otto Sánchez R., VETERINARIAN, Station Veterinarian, San Jorge (on study leave)
Plinio Sierra F., VETERINARIAN, Station Veterinarian, Tibaitatá
Eduardo Aycardi B., VETERINARIAN, Station Veterinarian, Tibaitatá

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Jorge Quintero P., M.S., Head of Engineering, Bogotá
Marco T. Arellano O., ING. CIVIL, Auxiliary Engineer, Bogotá
Fadrique Otero O., ING. CIVIL, Auxiliary Engineer, Bogotá
Jaime Ceballos O., ARCHITECT, Bogotá
Ramiro Cardona G., ARCHITECT, Bogotá (to March, 1962)
Luis Eduardo Patiño S., ING. AGR., Administrator, Palmira Station
Kamal Dow H., B.S., Agricultural Engineer, Acting Administrator, Turipaná

AGRICULTURAL INFORMATION

Milton E. Morris, PH.D., Technical Director, Assistant Information Specialist, The Rockefeller Foundation

Native Romosinuanos show excellent promise as a new beef breed.

Director's Introduction

The demand for additional food for the increasing population of Colombia is greater than ever before. Coffee, the principal export crop, is now in surplus in other parts of the world and prices and markets are uncertain. Efforts are being made to increase production of several food and cash crops to insure more foreign exchange. If meat, cotton, and other crops are to be produced in amounts great enough to feed and clothe the Colombian population adequately and in addition to furnish food and fiber for the world market, immediate improvement will have to be made in the efficiency and economy of agricultural production. The following report relates some concrete and rapid advances being made in agricultural research. It indicates that Colombia can be more than self-sufficient in foodstuffs and can hope to supply large quantities of food and fiber for other countries when the vast agricultural resources of the country can be placed in production.

PROGRESS

One of the primary objectives of the Colombian Agricultural Program continues to be the training of Colombian personnel. Although DIA was forced to reduce the number of trainees from the maximum, eight M.S. degree candidates and 14 Ph.D. candidates are at present studying in the United States. It is expected that five additional M.S. degree candidates will leave Colombia in June, 1962, for the orientation courses at Southern Illinois University and Cornell University, after which they will proceed to their places of study for the fall semester. During the year one Ph.D. and three M.S. degrees were earned by members of the DIA staff and these scientists have resumed their research work in Colombia.

Several corn hybrids and varieties have been released during the year. With the production of Diacol H-401, a yellow hybrid, and Diacol H-451, a white hybrid, improved varieties have now been released and distributed for each of the five distinct climates of the country. Seed sales are gradually increasing, but less than 10% of the country's needs for improved corn seed are being met. However, in the highly fertile Cauca Valley, 85% of the corn area is planted with hybrids.

As was expected to happen sooner or later, Nariño, the most recently released wheat variety, is being attacked by a new race of rust that is building up at various elevations, particularly in the southern part of the country. It is indeed fortunate that a reasonable quantity of the first multilineal variety will be ready for release by DIA at the end of this season to replace Nariño, if it is considered necessary. While it remains to be seen what the final advantages of a multilineal will be over a pure line variety, it appears that the useful duration of the former may be many times greater than that of the latter. The initial objection to the multilineal variety—the difficulty of breeding a large number of lines with resistance to different diseases, with good quality, and with the same phenotype—has been overcome with relative ease. This system seems highly feasible for future use as a breeding method with self-pollinated crops and should have wide application in many parts of the world.

Considerable delay has been experienced in replacing Funza, the first effort of the DIA barley breeding program released several years ago. Twenty-two hybrids which exceed Funza in yield and in several other respects are now awaiting the last quality tests before the final selection of two or three for increase. A micro-test laboratory is being purchased in order to speed up quality determinations.

The outlook for the oat breeding program is gloomy. A subrace of stem rust, designated 6C, has attacked every entry in the world collection and has rendered all varieties useless under Colombian conditions. Thousands of crosses made in Colombia and elsewhere have also been found susceptible to race 6C. This race also attacks Saia, a diploid type, found to be immune to most oat stem rust races in the United States.

Additional research funds, provided under United States Public Law 480, have been obtained by DIA for oat research. It is hoped that the search for resistance to stem rust can be intensified and that a variety resistant to local rusts can be found soon; otherwise there is not much future for oat production in Colombia. Furthermore, if 6C and similar virulent races of rust reach the north-central United States and other oat-growing areas, severe damage to the industry will undoubtedly occur.

Colombia offers unusual opportunities for studying the origin and development of crop species since corn, beans, potatoes, and various other crops almost certainly originated in the Andean zone. Several valuable wild species of potatoes have been collected for study and have been used in crosses to improve the crop. Three potato varieties, Diacol Cumbal, Diacol Sumapaz, and Diacol Capiro, have been released for commercial use and have given yields up to 1,000 bu./A. under ideal growing conditions. These varieties are highly resistant to late blight, the most important disease of potatoes in the area.

Work has continued on the potato storage building at Tibaitatá, and all refrigeration and insulation equipment has been purchased to complete the installation. These facilities will be used primarily to demonstrate that proper storage will contribute more than almost any other factor to stabilizing potato prices, a needed step toward the promotion of the industry and toward supplying potatoes to more people at prices they can afford.

The purchase of more equipment has given additional mobilization to personnel of the soil science program and has permitted more regional testing. Much of this work is being done in cooperation with the crop breeding sections. This kind of testing seems absolutely necessary since wider-range results are needed before definite recommendations are made for fertilizer use and for changes in certain other agronomic practices.

The revision of laboratory techniques and the division of labor between Tibaitatá and Palmira have greatly increased work efficiency. It is expected that efficiency can be increased still further by additional changes in procedures and by further training of laboratory personnel. Additional support for the soil program has been received from the *Corporación Autónoma Regional de la Sabana de Bogotá, Chiquinquirá y Ubaté* (CAR). These funds will be used mainly for water utilization and irrigation studies on the crops of the high altitude regions.

Much progress has been made during the year in placing the work on a project basis. This organization is necessary for long-range planning, proper balance, and adequate financing of the programs. One of the first to complete their projects and place their work on this basis was the forage crops section. The first varieties of forage crops have now been released and distributed to farmers. These varieties (discussed later in the report) include several high-yielding and disease-resistant species adapted to different elevations and climates of Colombia.

The bean program was the first of the DIA sections to achieve a staff trained to the level at which the direction of the program could be returned to Colombians. Several additional programs including corn, forage crops, rice, plant pathology, entomology, and wheat should be ready for return to local personnel within the next two to three years, as soon as candidates now on fellowships come back from the United States with Ph.D. degrees.

Several new varieties of beans, peas, and cowpeas have been released. Improved strains of one or the other of these crops have now been distributed for all of the climates of Colombia.

A proposed P. L. 480 project for the collection, preservation, and study of indigenous beans is of utmost importance because the Andean bean varieties will disappear rapidly once improved types are distributed to farmers. It is hoped that this project may be supported and initiated before the highly variable local varieties of beans have disappeared and before irreplaceable germ plasm is lost.

Valuable information on the virus disease of rice, "hoja blanca," has been obtained from the nurseries furnished by the United States Department of Agriculture. Additional information on cultural practices and fertilizer use in rice is almost ready for distribution to farmers. The control of weeds, particularly monocotyledonous plants, in rice fields is one of the most serious cultural problems. A chemical weed-killer, STAM F-34, continues to show great promise, especially in the control of barnyard grass, *Echinochloa colonum*, the weed most difficult to control.

The plant pathology program and the potato program held their annual meetings with plant pathologists and potato breeders from various Andean countries attending. It is considered that the practice of inviting scientists from other countries to attend these meetings will do much to stimulate the technical workers and to help them exchange information and valuable plant materials.

Completely controlled beef fattening trials are being conducted for perhaps the first time in the Savannah of Bogotá by the beef cattle program. Gains up to 2.8 lbs. per steer per day have been obtained during the trials. These gains would be considered satisfactory almost anywhere in the world. High-quality meat is not fully appreciated in Colombia and no premium is paid for quality, so it will probably be some time before the real value of these experiments can be fully realized. However, dry-lot feeding of beef is economical even under present price conditions, particularly if forage grown during the rainy season is consumed as silage by the animals during the dry period when there is a dearth of forages.

Extreme difficulty has been experienced in obtaining sufficient numbers of animals for experimental work. DIA was able to import only 52 head of high-quality Holstein heifers during the year, and no beef or other stock animals were imported. Some of the dairy animals were kept at Tibaitatá and the others were sent to Nariño in the southern part of the country.

According to the Holstein Association of Colombia, the herd at Tibaitatá produced the highest milk average in the country, 12,254 lbs. per cow in 1961. Management and nutrition are difficult locally because the high price of feed grains often renders the cost of a good diet uneconomical.

Feeding experiments have demonstrated that calves can be given dry-feed rations and no milk after 56 days here, as well as elsewhere, with the consequent release of large amounts of milk for human consumption. This more economical system of raising calves will also help to reduce the slaughter of potentially valuable male and female stock animals at birth.

The poultry program has increased its research work at Tibaitatá, Palmira, and Tulio Ospina. This program is already making a valuable contribution to the economy of poultry production, and it is expected that its benefits will increase as soon as an optimum size and scope of program are reached. The greatest limiting factor at present is the high cost of feedstuffs, especially grain and protein supplements. When these are fed to animals it raises the economic question of utilizing them for animal feed or for direct human consumption.

The sheep industry in Colombia faces numerous problems of disease, operational, parasite, and climatic origin. Additional sheep parasitic species have been identified during the year, bringing the known total to 16. Any one of these could be a limiting factor in the success of the sheep industry. Nevertheless, progress is being made in solving some of the problems.

Excellent results and highly satisfactory gains in weight have been obtained with swine, the animals weighing up to 105 kg. in 150 days. However, as with the other species, the high cost of feedstuffs will probably be the limiting factor in development of this industry. At present, experiments are being conducted to test non-grain sources of high energy feeds; if these prove useful, the cost of pork production may be greatly reduced.

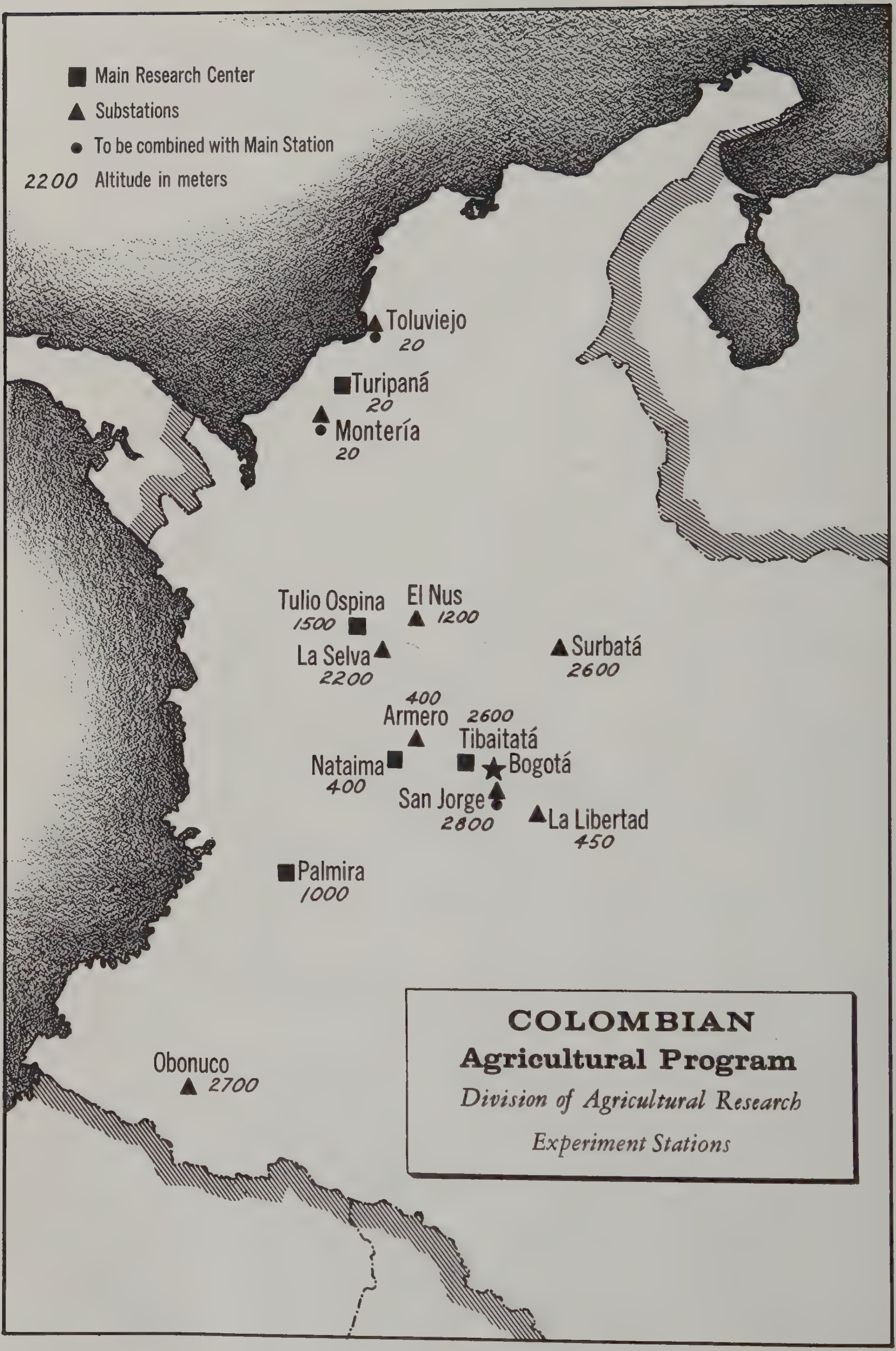
Plans for the Veterinary Research Laboratory have been completed, but construction will probably not start until the laboratory and the institute's program can be fully coordinated.

The simultaneous development of several experiment stations continues to tax the budget and facilities of DIA. Much remains to be done before DIA will be able to concentrate more on research and less on the developmental phases of its program.

An extension information program was started during the year. No Colombian technical personnel have been engaged to staff this program, but positions have been approved and will be filled as soon as suitable candidates are found.

Several staff changes occurred during the year. Dr. William Hatheway was transferred to the Inter-American Food Crop Improvement Program, and Dr. Peter Jennings to the International Rice Research Institute in the Philippines. Dr. Dale Harpstead joined the CAP staff as technical director of the corn program, and Dr. Milton Morris joined the program as technical director of the extension information program. Dr. Robert Ruppel resigned to join a chemical company in New York.

The staff has participated in a number of activities outside the CAP. Six members attended the International Plant Science, Soil, Entomology, and Plant Pathology Congress held in Argentina in November, 1961, and several members have continued to participate in the inter-American food programs, particularly in Venezuela and Ecuador.



COLOMBIAN
Agricultural Program
Division of Agricultural Research
Experiment Stations

Experiment Stations of the Division of Agricultural Research, Ministry of Agriculture, Colombia.

Location	Name	Size (acres)	Altitude (meters)	Av. temp. (°F.)	Av. rainfall (inches)	Soil types	Principal fields of investigation	Type of agriculture in region served
MAIN STATIONS								
Bogotá, Cundinamarca	Tibaitatá	1,404	2,600	57	29.55	Clay and silt loam	Corn, small grains, potatoes, beans; Horticulture; Forage crops; Soils; Entomology; Animal sciences; Plant and animal pathology	Diversified: all crops and animals
Medellín, Antioquia	Tulio Ospina	408	1,500	70	63.04	Loam	Corn, beans; Soils; Entomology; Plant pathology; Poultry	Corn, beans; Beef and dairy animals
Palmira, Valle del Cauca	Palmira	943	1,000	75	40.98	Clay loam	Corn, rice, beans, sugar cane, vegetables; Soils; Entomology; Plant pathology; Animal sciences	Corn, rice, beans, sugar cane; Soybeans; Pasture crops; Poultry; Cotton
Espinal, Tolima	Nataima	553	400	83	68.56	Sandy loam	Rice, vegetables; Forage crops; Soils; Entomology	Corn, rice; Sesame; Cotton; Beef animals
Cereté, Córdoba	Turipaná	4,495	20	82	41.76	Clay loam	Corn; Forage crops; Entomology, Animal sciences; Plant and animal pathology	Corn; Cotton; Beef animals
SUBSTATIONS								
Pasto, Nariño	Obonuco	1,421	2,700	55	35.46	Silt loam	Small grains, potatoes; Entomology; Dairy animals; Plant and animal pathology	Small grains, potatoes; Beef and dairy animals
Duitama, Boyacá	Surbatá	184	2,600	59	31.13	Clay	Small grains, potatoes	Small grains, potatoes; Beef animals
Soacha, Cundinamarca	San Jorge	1,929	2,800	56	27.58	Clay	Sheep; Animal pathology	Sheep; Potatoes
Rionegro, Antioquia	La Selva	168	2,200	63	55.16	Silt loam	Corn, potatoes, beans, vegetables; Forage crops; Entomology; Plant pathology	Corn, potatoes, beans; Dairy animals
Villavicencio, Meta	La Libertad	3,336	450	79	167.84	Loam	Beef animals; Animal pathology	Rice; Beef animals
San José, Antioquia	El Nus	2,716	1,200	75	88.73	Loam	Beef and dairy animals; Animal pathology	Beef animals
Armero, Tolima	Armero	1,656	400	84	72.89	Sandy loam	Beef animals; Animal pathology	Corn, rice; Sesame; Cotton; Beef animals
Toluviejo, Bolívar	Toluviejo	2,660	20	82	22.66	Sand	Beef and dairy animals; Animal pathology	Cotton; Beef and dairy animals

Supplemental moisture is used to increase corn yields in Colombia.

Corn

The corn production of Colombia is used primarily for human food and is a basic source of carbohydrate for a large portion of the population. This method of utilization has resulted in the expression of strong sociological preferences for certain types of grain. In the warmer climates flint-type grains are demanded while flour-type grains are wanted at the higher elevations. These preferences limit the range of material which the plant breeder can utilize in breeding programs for the various regions.

Statistics of corn production indicate that the areas of largest production are regions where agriculture is carried on in narrow mountain valleys and along steep slopes. Production in these areas is chiefly by hand operation in a subsistence-level type of agriculture. Under these conditions yields are low and the bulk of the production is for local or family consumption. In the more highly developed agricultural regions, where corn is grown in a mechanized commercial system, per-acre yields have increased substantially in recent years. The increases have closely paralleled the sale of improved seeds, which has risen from 624 metric tons in 1956–1957 to 843 metric tons in 1960–1961. No sharp increases in the corn acreage have been noted in these areas, probably because of the competitive market advantage of cotton and sugar in the present world situation.

BREEDING PROGRAM

RELEASES

Substantial improvement in corn hybrids and varieties for Colombia was made during 1961. Breeding and testing were completed on eight new seed stocks, which have been approved and released for seed multiplication and commercial production.

Two hybrids—Diacol H-401, a yellow flint type, and Diacol H-451, a white flint type—were released for use in the zone of 1,700–2,200 m. elevation. These were developed at the La Selva station and represent the first improved material released for this altitude range.

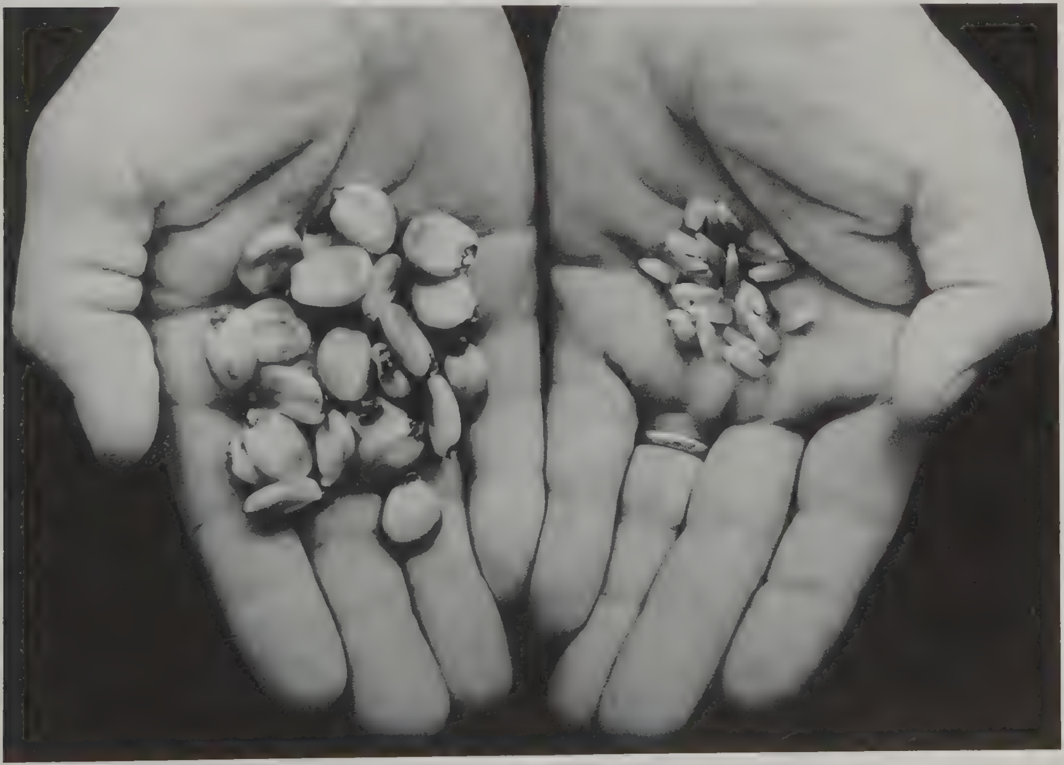
Three new seed stocks were released from the Palmira station in the Cauca Valley. A new white hybrid, Diacol H-253, with improved grain quality and high yield was developed to replace a widely grown hybrid now in production. In addition, two other varieties were released for production: Diacol V-254 and Diacol V-206. The former is a white grain type with improved grain quality and a 15–20% yield advantage over an existing improved variety. Diacol V-206, a yellow variety which matures about 20–25 days earlier than existing commercial varieties, is designed to fit into a cotton-corn rotation in the Cauca Valley region.

The materials released from the Montería station, in the northern coastal region, include one new hybrid, Diacol H-152, and two new varieties, Diacol V-103 and Diacol V-153. These represent considerable progress in corn improvement for low elevation areas. Improvement has been made not only in yield and quality but also in resistance to leaf and stalk diseases which are major yield-reducing factors in this area.

The release of both hybrids and varieties is noteworthy because of the difference in the characteristics of these materials. To make maximum use of the advantages of the hybrid, new seed must be purchased each year from stocks produced under rigorous pollination control. The release of a variety provides the grower with a seed stock which can be replanted from his commercial production over a period of several years before it is necessary for him to buy new seed. While the variety can be expected to yield somewhat less than the hybrid, its average performance over several years will be superior to that of a hybrid which has been reproduced from seed harvested from the commercial field.

SPECIAL STUDIES

Special consideration continues to be given to breeding methods which will lead to production of improved varieties. This program is designed to complement the hybrid corn breeding program. The production of corn



Differences in size illustrate some of the genetic variation available in the Andean corn germ plasm bank.

varieties should make possible the future release of material which will have a broader range of adaptation and be generally more tolerant to seasonal environmental changes.

Early in these studies it became apparent that additional information was needed about the mode of gene action and the frequency of favorable genes. Studies designed to clarify these problems are being continued.

The outstanding performance of several varieties when used in variety crosses has led to further investigation of these materials as sources from which improved corns could be derived. At Tibaitatá the cross between Rocamex V-7 and Harinosa Mosquera exceeded the yield of Harinosa Mosquera by 90%. Reciprocal recurrent selection progenies from within each of these varieties have exceeded the yield of the original variety by 6% in Rocamex V-7 and 34% in Harinosa Mosquera. Selections made within the variety Nariño 330 were tested at Tulio Ospina as four composites made up of 7, 11, 16, and 41 lines each. The yield advantages for these composites over the unselected variety were 33%, 27%, 31%, and 18%, respectively. Studies such as these continue to provide information on the basic materials available to the plant breeders and will in the future enable these stocks to be more efficiently utilized.

COOPERATIVE STUDIES

The corn section has continued to cooperate with the entomology and plant pathology sections. Inbred lines used in the hybrid programs are subjected to the testing and evaluation programs of these sections. Breeding programs designed to select materials with superior insect resistance are also in progress.

The appearance of a disease problem in corn, tentatively identified as the virus disease, corn stunt, was noted at Tulio Ospina. This disease caused considerable damage in the breeding nurseries and yield trials.

PRESERVATION OF GERM PLASM

The extensive corn collections made throughout the Andean regions of South America are being maintained in storage at the Tulio Ospina station near Medellín. These stocks represent a large portion of the known genetic diversity in the corn species. Seed from approximately 6,000 collections is maintained under conditions of controlled temperature and humidity. It is probable that many of these collections are irreplaceable and must be maintained from the stocks now in storage. These materials are described in bulletins published by the National Academy of Sciences—National Research Council in Washington, D.C.

The storage and maintenance of this seed does not accomplish the desired ends unless the seed can be utilized in breeding programs and fundamental studies. During the past year, 29 requests for seed from outside of Colombia were filled from these stocks.

MISCELLANEOUS

In 1961 two agronomists from the corn section began work toward their Ph.D. degrees at universities in Missouri and New York. Both individuals had previously earned a Master's degree in the United States.

A new element has been introduced into the seed increase and sales picture of Colombia. This came with the formation of the first privately owned hybrid seed corn company which began its operation in the Cauca Valley region. It is anticipated that the development and cooperation of private enterprise can substantially increase the effectiveness of corn improvement programs in general.

Colombian wheats are widely adapted: Nariño, grown at Huancayo, Peru.

Wheat

Seven new hybrid-derived wheat varieties were selected in 1961 for multiplication in 1962. Selection was based on agronomic and disease-resistance performance since 1958 in regional and experiment station trials in the States of Cundinamarca, Boyacá, and Nariño. Yield, rust reaction, percentage of "vaneamiento,"* and bread quality are given in Table 1. All seven yield better than either the newest commercial variety, Diacol Nariño, or the standard check, Bonza, the yields ranging from 56 to 82 bu./A. All have acceptable rust resistance and bread quality. Additionally, the variety Africa-Mayo × Frocor, Cross II-11992, makes very acceptable spaghetti. The two varieties, Frocor-Frontana/Yaqui × Nariño sib, Cross II-9313 and Frocor (Newthatch/Mentana^2-Kenya × Bagé) × Gabo, Cross II-11263, plus sister selections are also being multiplied in Ecuador for release there.

In the State of Nariño, the adapted commercial variety, Diacol Nariño, is moderately susceptible to stem rust below elevations of approximately 8,500 feet, and needs replacing. The following varieties have demonstrated resistance to stem rust (*Puccinia graminis* var. *tritici*), yellow rust (*Puccinia glumarum*), "enanismo" (a virus disease transmitted by the leafhopper *Cicadulina pastusae*), and vaneamiento, and are being multiplied and further tested in regional trials and also for quality:

1. Africa-Mayo × Frocor
2. Yaqui 53 × Bonza-Kenya AJ
3. Frocor-Frontana/Yaqui × Nariño sib
4. (Frocor × Santa Catalina/Kenya × Frocor-Newthatch) × Frocor^2
5. Yaktana sib × Frocor^2

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* The term "vaneamiento" describes a spike sterility usually found in grain fields in relatively narrow valley bottoms. It is caused by brusque temperature changes resulting from an inflow of cold air from the surrounding mountains that kills pollen cells and prevents seed set.

TABLE 1.

Average yields, resistance to rust and vaneamiento, and bread quality of promising wheat hybrids in multiplication. States of Nariño, Boyacá, and Cundinamarca, 1958–1961.

Name and number of hybrid or variety		Yield in % of Bonza[a]	No. determinations[b]	RUST[c]		Vaneamiento[d]	Bread quality
				Yellow	Stem		
Rio Negro × Bonza	VI-36-2-30b-2t-1b	174	9	10MR	0	—	Good
Africa-Mayo × Frocor	II-11992-1t-6b-1t-1b	154	8	TR	0	—	Excellent
Frontana-Yaqui × Bonza^3	VI-10-2-2-14b-1t-2b	147	15	10MR	0	—	Good
Yaqui 53 × Bonza-Kenya AJ	II-10408-8t-1b-1t-1b-1t	135	124	TR	0	1	Good
Frocor-Frontana/Yaqui × Nariño sib	II-9314-22t-1b-1t	130	138	TR	0	4	Good
Frontana/Yaqui-Mayo 54 × Menkemen	II-10668-4t-2b-1t	126	141	TMR	0	3	Very good
Frocor (Newthatch/Mentana^2-Kenya × Bagé) × Gabo		119	94	5MR	0	25	Very good
Nariño (Improved check)		117	150	0	10MR	17	Very good
Bonza (Standard check)		100	150	20MR	TMR	46	Good

[a] Yield of Bonza was 47 bu./A.

[b] Each determination was based on data from one plot of three rows 1 rod long.

[c] Recorded as percentage of attack and reaction. T = trace, R = resistant, MR = moderately resistant.

[d] Expressed as percentage of florets that did not set seed; 100% = complete loss. Data are from notes taken only in the two affected zones (northern Savannah of Bogotá and Rosal del Monte, Nariño).

6. Frocor/Mayo 54-Nariño sib × Frocor^2
7. 1879/Mayo 54-Bonza × Frontana/
   Urquiza × Thatcher/Mentana
   (two lines)

The best of these varieties will be further multiplied and released to the Caja Agraria for commercial distribution.

The breeding program to produce wheats for the hot climates was continued at Palmira. The good-quality, high-yielding, adapted variety, St.464 × Bonza sib, Cross II-7458, was selected from yield trials in 1961. It and the previously selected variety, Thatcher-Santa Catalina × Frocor, Cross II-5962, will be multiplied as rapidly as possible, and regional testing will be started in 1962.

Before a hot climate wheat can be released to farmers, it will be essential to work on cultural practices and weed and insect control. Weeds and insects are especially serious in the warmer zones, and control measures must be found. Fertilizer requirements and dates and rates of planting also need study.

Major emphasis is being placed on the multiline breeding program to produce a composite Frocor variety for the northern zone of the Savannah of Bogotá where yellow rust and vaneamiento are a problem, and to produce later a composite for the State of Nariño. A group of 125 varieties, including the lines in multiplication previously mentioned, plus 80 selected Frocor lines were planted in yield trials in the vaneamiento zones of Cundinamarca and Nariño. On the basis of agronomic data and resistance to diseases and vaneamiento, 18 Frocor lines were reselected and are being multiplied. These will be reduced to 10, the seed mixed, and the resulting mixture released through the Caja Agraria as a Frocor composite variety. Table 2 lists the yield, percentage of vaneamiento, and rust reaction of some of the individual lines compared with four checks.

Average yields ranged from 23 to 46 bu./A. and all outyielded every check variety except in the vaneamiento zone, where three of the individual lines yielded less than Menkemen.

Menkemen is still the variety most commonly grown in the northern Savannah of Bogotá, largely because it is very tolerant to vaneamiento. However, if conditions are severe enough, as happens occasionally in the Rosal del Monte region of the State of Nariño, even Menkemen will be damaged. In spite of this tolerance, it is not a variety which is generally recommended, since it is

A cooperative project with the soil section demonstrating effect of fertilizer on Nariño wheat in Ecuador. Initial "E" written with a complete fertilizer.

TABLE 2.

Average yields and resistance to rust and vaneamiento of some of the Frocor lines in multiplication to form a Frocor composite variety. States of Nariño, Boyacá, and Cundinamarca, 1959–1962.

Name and number of hybrid or variety		Average yield in % of Bonza[a]		Vane-amiento[b]	RUST[c]	
		All locations	Van. zone		Yellow	Stem
(Timstein/Chinese-Kenya Farmer)-(Lerma × Newthatch/Marroqui^{2}-Maria Escobar) × Frocor^{3}	II-12760	143	208	7	0	0
(Frocor × Kenya 340-Lerma/RF 2306) × Frocor	II-11219	142	200	3	TMR	0
Kentana-Thatcher/Mentana × Frocor	II-11380	137	147	13	TR	0
(Zipa-Kenya AD/Gb × Nariño sib) × Frocor^{2}	II-11145	136	184	12	5MR	0
Kenya 58/Newthatch-Frontana × Frocor^{2}	III-63-6	135	205	5	TMR	0
(150-Frocor × Kentana-Egypt/Timstein) × Frocor^{2}	II-11203	133	195	6	TMR	0
(Nariño sib × Frocor/Cinco-Mayo 54) × Frocor	II-9982	131	171	5	0	0
Marroqui-Renown^{2} × Frocor^{3}	III-28-6-6	131	208	6	TMR	0
Frocor^{3} × Maria Escobar-H 44/Marquis	III-78-6-6	130	160	11	0	0
Kenya AJ × Frocor^{3}	III-17-6-6	129	169	4	5MR	0
Lee-Frontana × Frocor^{3}	III-23-6	125	173	4	5MR	0
Yaqui-Kentana × Frocor^{3}	III-120-6-6	122	168	13	5MR	0
Frontana-Kenya 58/Newthatch × Frocor^{3}	III-8-6-6	120	184	6	0	0
Nariño (Newest improved check)		147	118	17	0	10MR
Menkemen (Vaneamiento-resistant check)		114	163	2	30S	30S
Bonza (Vaneamiento-susceptible check)		100	100	46	20MR	TMR
Frocor (Recurrent parent)		96	120	12	TMR	20MS

[a] Yield of Bonza at all locations was 26 bu./A.; in vaneamiento zone, 17 bu./A.

[b] Expressed as percentage of florets that did not set seed; 100% = complete loss. Data are from notes taken only in the two affected zones (northern Savannah of Bogotá and Rosal del Monte, Nariño).

[c] Recorded as percentage of attack and reaction. T = trace, R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible.

susceptible to stem and yellow rust which markedly reduce its test weight per bushel.

The stem-rust readings in Table 2 all came from the Rosal del Monte zone of Nariño in southern Colombia where a very virulent race or group of races of stem rust are being propagated on the susceptible Menkemen variety and to some extent on the variety Diacol Nariño. As yet none of these races has appeared in northern Colombia; if they do, there are approximately 2,000 additional Frocor lines in reserve that can be tested for resistance and the composite remade with resistant lines. Very little is known about the epidemiology of either stem or yellow rust in Colombia, but the tropical valleys and high mountain ranges, and the long distances between the southern and northern wheat zones should offer some degree of protection against rapid spread.

Several basic studies to compare yields of composite mixtures with average yields of the individual lines, as well as of the influence on yield and disease resulting from substitution of lines, are being initiated with the Frocor multiline variety.

During 1961, a total of 25,333 wheat lines were sent to Argentina, Bolivia, Chile, Ecuador, Guatemala, Mexico, Peru, Italy, Angola, Israel, Kenya, and the Philippines.

Commercial-size barley plantings, Tibaitatá.

Barley

There has been an increasing demand that the improved barley variety Funza be replaced by a stronger, stiffer strawed variety because, with increasing fertilizer use, the farmers of Cundinamarca and Boyacá need a barley which is resistant to lodging. The malting companies would also like a variety with plumper grain and a higher extract percentage.

To meet this need, 64 selected varieties were released to the Bavaria Malting Company for quality testing. At the same time they were increased in small multiplication plots and were also tested for yield at the experiment stations and in regional trials. On the basis of yield, grain plumpness, and agronomic and quality data, 22 were selected for preliminary multiplication. All are stiff-strawed, resistant to lodging, and better-yielding than Funza. With the exception of one, all are equal to or better than Funza in smut resistance, and two are nearly immune. Their reaction to other diseases is acceptable though none is highly resistant.

Even Pocha-Kindred × Bachue[3], Cross 1665-8b-3t, with the lowest quality of those tested, has been accepted by the malting industry; consequently, all the others are acceptable from a quality standpoint.

The breeding program at the Obonuco station in Nariño has produced plump-grained, early maturing barley varieties with excellent agronomic type that are highly resistant to "enanismo," a virus or virus-like disease transmitted by the leafhopper, *Cicadulina pastusae.* A group of 207 was sent to the Bavaria laboratory for quality testing. When the results are known, the best will be multiplied to replace the variety Galeras in the State of Nariño. Galeras is a stiff-strawed, medium early, high-yielding, enanismo-resistant variety, but it has low quality and a thin, long kernel with a very low percentage of No. 1 size grains. This defect reduces farmers' returns since grain size affects price.

Enanismo, up to now, is found only in the State of Nariño and further south in Ecuador and Peru. However, if it should move north into the cereal zones of Cundinamarca and Boyacá it might be disastrous for the barley industry, since all the varieties in these areas are completely susceptible. To combat this threat, 350 of the best enanismo-resistant barley hybrids from Nariño were crossed with the high-quality varieties Toluca, Funza, Traill, Kindred, and Manchuria. A total of 1,321 crosses was made, each of which will be backcrossed to the quality parent next semester.

Procebada, the organization promoting Colombian barley production, has commissioned six agronomists to the breeding program and one for regional trials.

More than 90% of the barley produced in Colombia is used for malt; consequently malting quality is a very important factor in the breeding program. Procebada has provided funds for a micro-malting laboratory to test barley hybrids from the breeding program and it is expected that this laboratory will soon be in operation.

Oats

The oat improvement program during the past year has been devoted almost entirely to a search for sources of resistance to oat stem rust, since this disease remains the limiting factor to oat production in Colombia. No variety or line from any source has shown field resistance to the rust race complex present in Colombia. This statement applies not only to locally produced material but also to all promising lines from the United States and Canada available for testing.

During the year new seed of the U.S. Department of Agriculture world oat and species collections was obtained. The lines added since the collection was last grown in Colombia were screened in the field and by greenhouse testing to individual races. All of the 4,418 entries in these two nurseries and a number of other lines sent especially for the purpose were susceptible in the field.

Sufficient information is available from race identifications made by the plant pathology section to show that several new biotypes of the oat stem rust pathogen are present in Colombia (see report of the plant pathology program). One of these new subraces, 6C, was selected for the first greenhouse screening of oat material with a single, purified rust race. Subrace 6C was chosen because of its extreme virulence—it is able to attack all the commonly used standard and supplementary differentials, including the diploid oat, Saia. The U.S.D.A. world oat and species collections, a number of locally produced lines, and promising lines from various other sources were planted for seedling tests in cooperative trials with the plant pathology section. Only two plants of two different lines showed seedling resistance to 6C, and both proved completely susceptible when inoculated in the adult stage. No adequate source of resistance has yet been found to this single subrace.

While all the present material is susceptible to 6C in the seedling stage, it is possible that some lines may carry adult resistance. It would not be possible to observe this at Tibaitatá, Surbatá, or Obonuco because of the confounding effect of other races. For such a test a rust-free area is needed into which 6C could be introduced without endangering nearby oat fields or susceptible grasses. A location with these conditions is being sought to avoid the vagaries of greenhouse screening for adult resistance.

Such an extremely virulent complex of races represents a serious threat to oat production in the entire hemisphere. As the situation becomes better known to U.S. and Canadian workers, they are showing considerable interest in the problem. Mr. D. E. Western of the Quaker Oats Company, Dr. H. C. Murphy of the U.S.D.A., and various other workers have visited the program and have been cooperative in supplying material and in making valuable suggestions. In view of the potential threat to United States oat culture, a Public Law 480 project has been approved for further study of the problem.

Certain oat lines have been observed which have markedly smaller than normal rust pustules under field conditions. Notes on this character, which appears to be partial resistance or tolerance, were taken during the year on well-adapted Colombian material and the U.S.D.A. world oat collection, and experiments were initiated to evaluate the potential utility of the trait. Preliminary experiments have shown a decided advantage for lines with this character, both in yield and 200-seed weights.

Since partial resistance has rarely been utilized for the control of cereal rusts, more fundamental knowledge is required to assess the practicability of such a system.

The local division of the Quaker Oats Company has continued its support of the breeding program by supplying a generator to run the growth cabinets used in the race identification work and by providing an agronomist to work in the breeding program.

Harvesting experimental rice plots, Nataima.

Rice

In the search for better rice varieties, the rice program selected approximately 2,000 plants which were resistant to a heavy hoja blanca attack at Palmira in 1961. These were the fifth generation progenies of crosses made in 1959.

At both Palmira and Nataima, progeny from 1958 crosses were selected on the basis of their long grain, hoja blanca resistance, and good agronomic qualities. The 56 pure lines of this selected group will be used for new yield tests in 1962. It may be possible to use them also in regional tests conducted in cooperation with the National Rice Federation.

The fungus *Cercospora oryzae* attacked rice at the Nataima station during the second semester of 1961. Many crosses and selections were resistant and will be used in the breeding program in the future. At Nataima and Palmira 15,170 varieties and lines were studied and classified, providing material for future investigations.

The rice program is benefiting from increasing national and international cooperation by several important groups. Technical personnel from the National Rice Federation have been assigned to the rice program of DIA. This has aided progress at a time when several DIA technicians were studying abroad.

Under supervision of the rice program staff, the National Rice Federation planted regional trials with some of the promising varieties. Another cooperating agency, the U.S. Department of Agriculture, sent 3,974 lines in different generations for hoja blanca tests at Palmira. Using this and Venezuelan material, it has been possible to select 277 lines with long grain and hoja blanca resistance.

The Japanese Embassy in Colombia are also interested in collaboration with the rice program. They furnished seed of 14 varieties for tests at Palmira, but unfortunately all were susceptible to hoja blanca.

In the first semester of 1961, 126 lines were planted in observation plots and 103 in the second semester. The first yield tests were harvested during 1961. Twenty-four improved varieties were compared with four local varieties. This group of 24 had material with good agronomic characteristics, disease resistance, and yield. Eleven of these were selected for more testing in new yield trials and three varieties will be used in multiplication plots.

CULTURAL METHODS

Another part of the rice program in 1961 was a study of planting rates. Tests showed that 150 kg./ha. of seed gave best results. This agrees with the findings of 1960. Phosphorus and potassium applications at different rates and at different growth stages did not influence yield. There was a response to nitrogen application, with about 150 kg./ha. giving the best results.

A Palmira test compared ratoon cultivation with direct planting. The following conclusions were drawn: (a) yields from direct plantings were larger than yields from ratoon cultivation; (b) ratoon cultivation caused a more pronounced reduction of nitrogen, phosphorus, and potassium elements; (c) although production costs with ratoon cultivation are less, lower yields indicate that this form of rice cultivation is not justified in Colombia.

Weeds are one of the biggest problems of rice cultivation in Colombia, causing a large production loss and requiring time and money for control. With this in mind, the rice program has emphasized studies to find the most efficient and economical weed control for rice. During 1961 a test was made at Palmira to determine the effectiveness of the dinitro-ortho-s-butyl phenol products, pentachlorophenol (PCP), and aromatic oil as weed controls. Although the best results were observed in plots treated with PCP, the high cost of this chemical limits its use.

Tests were made in several places to study the efficiency of the post-emergence herbicide STAM F-34 (3, 4-dichloropropionanilide) as a control of *Echinochloa colonum* L., the worst weed in rice. Results showed that 6.66 kg./ha. gave effective control for up to 25 days.

OTHER WORK

DIA gave an intensive training course for the agronomists of the National Rice Federation. Because of the success of this course, a second one will be offered as soon as it is possible.

Irrigation in a demonstration lot at Palmira.

Beans

The annual report for 1957 included a summary of seven years of research on bean improvement; the present one covers the period after that date. The bean section is also responsible for improvement work with peas and cowpeas. Since October, 1957, the program has been entirely directed by Colombian scientists.

BEANS

The bean program has concentrated on obtaining bush varieties with good yield, good marketing qualities, and disease resistance that are adapted to the different climatic regions of Colombia. Improved varieties and better cultural practices have aided increased production per unit of area.

Breeding and testing are conducted at six experiment stations: Palmira (altitude 1,000 m.), Tulio Ospina (1,500), Tibaitatá (2,600), Nataima (400), Surbatá (2,600), and La Selva (2,200).

RELEASES

In the period of this report three new bean varieties were released to farmers through the *Caja de Crédito Agrario*, the agricultural credit bank which has responsibility for seed multiplication and distribution: Diacol Nima in 1959, Diacol Andino in 1960, and Diacol Catio in 1961. From 1958 to 1960 the program furnished the Caja with 2 tons of basic seed of Diacol Nima and 1 ton of Diacol Andino seed. The Caja sold a total of 32,100 kg. of these new varieties in 1961, enough to plant 535 hectares having a potential production of about 900,000 kg. If all this production were used for seed it would fill all farmer requirements for 1962. A facilitating factor in the adoption of new bean varieties is that, properly handled, the seed from one crop can be used for planting subsequent crops without the necessity of purchasing new seed.

Diacol Nima, bred at Palmira, is adapted to moderately warm climates at 800 to 1,200 m. altitude. The seed is red with cream-colored spots, has good size and quality, and is well accepted by consumers. It has yielded an average of 1,500 kg./ha., is drought tolerant, and resists or is tolerant to many of the diseases such as angular leaf spot which frequently occur in the Cauca Valley, where the variety is quite popular. It is, however, moderately susceptible to rust.

Diacol Andino, a product of work at Tibaitatá, is the first bush variety in Colombia released for the cold climate at high altitudes. Its 150- to 160-day vegetative period permits two plantings a year or rotation with wheat, potatoes, or barley. Diacol Andino is resistant to certain diseases, has oval-shaped seed, is shiny pink with red stripes, and enjoys good acceptance in local markets. It yields 1,500 to 2,000 kg./ha., and data for six years show it outproduces local varieties by 134%.

Diacol Catio, produced at Medellín, is adapted to altitudes between 1,000 and 2,200 m. It is an erect bush type with high yield, matures in 80 to 85 days, and has red seed with colored spots. It cooks quickly, has an agreeable flavor, and is popular with consumers. Diacol Catio is resistant to the more common diseases in its zone of adaptation and is immune to anthracnose. Although it is slightly susceptible to rust and angular leaf spot, attacks of these pathogens do not appear to affect yields seriously. It is slightly tolerant to gray blotch and floury blotch.

Diacol Nima and Diacol Catio were derived from a cross between the local variety Algarrobo and a Peruvian collection. Yields of these two varieties are shown in Table 1. Diacol Catio results from a cross between two local varieties.

COLLECTION

During the past 12 years the bean program has been gathering and studying a collection of bean varieties from four continents to establish a germ plasm bank for use in Colombia and other countries. From 1958 to 1960, 1,225 collections were studied. In 1961, 650 varieties were planted in three different areas of Colombia; in most of these, pure lines were established. In addition, 120 lines with black seeds were planted in the hot climate region, about 400 m. in altitude, to determine adaptation. In this region a good variety would be valuable for cultivation in rotation with cotton.

In 1961 plans were presented to initiate two projects to be financed from Public Law 480 funds with the approval of the United States Department of Agriculture. One is to complete the collection of indigenous cultivated and wild beans in the Western Hemisphere; the other is to evaluate more thoroughly the

TABLE 1.

Yields (kg./ha.) of two improved varieties and four commercial varieties at Palmira during five semesters.

Variety	SEMESTER[a]					Av. yield
	1958B	1959A	1959B	1960A	1960B	
Diacol Catio	1,689	1,542	2,130	584	1,080	1,405
Diacol Nima	1,810	1,580	1,922	629	1,117	1,412
Sangretoro	952	1,177	1,660	262	972	1,005
Híbrido Japones	846	622	1,526	266	844	821
Panameño	653	1,121	656	149	540	624
Algarrobo	592	1,274	430	448	216	592

[a] Letters A and B indicate 1st and 2nd semesters, respectively.

TABLE 2.

Incidence of bean diseases at different experiment stations.

Disease	Palmira	Tibaitatá	T. Ospina	Nataima	Surbatá	La Selva
Common blight (*Xanthomonas phaseoli*)	I[a]	II	I	I	P	I
Rust (*Uromyces phaseoli* var. *typica*)	I	I	I	I	II	II
Common bean mosaic (Bean Virus 1)	I	P	II	I	I	II
Angular leaf spot (*Isariopsis griseola*)	II	P	I	P	I	I
Anthracnose (*Colletotrichum lindemuthianum*)	—	I	I	—	I	I
Powdery mildew (*Erysiphe polygoni*)	P	P	P	P	P	II
Gray blotch (*Cercospora vanderysti*)	—	—	I	—	—	I
Floury blotch (*Ramularia phaseolina*)	—	—	I	—	—	I
Cercospora leaf spot (*Cercospora canescens*)	I	—	P	—	—	—
Ascochyta leaf spot (*Ascochyta phaseolorum*)	—	P	I	—	—	II
Halo blight (*Pseudomonas phaseolicola*)	P	P	II	—	—	P
Rhizoctonia root rot (*Rhizoctonia solani*)	P	II	I	—	—	P
Southern blight (*Sclerotium rolfsii*)	II	—	II	—	—	—
Sclerotinia wilt (*Sclerotinia sclerotiorum*)	—	I	—	—	—	—

[a] I = severe, II = moderately severe, P = present.

Colombian collection for reactions to diseases and insects.

VARIETAL IMPROVEMENT

The bean breeder in Colombia faces a complexity of problems. Most of the diseases known to attack beans are present, their severity varying among the different bean-growing areas (Table 2). Prolonged droughts or excessive moisture in different regions make it necessary to breed for resistance or tolerance to these conditions. The local varieties with acceptable color and size are generally susceptible to diseases and insects, and consequently have low production. In addition to these conditions, the breeder must also deal with consumer preferences, especially as to seed color.

The diseases also vary from season to season. Angular leaf spot (*Isariopsis griseola* Sacc.) was very severe in 1955 and 1957, and occurred with serious results in 1961 in the States of Valle del Cauca and Antioquia, and less severely in Boyacá. The seriousness of the last outbreak made certain changes necessary in the breeding program.

Anthracnose [*Colletotrichum lindemuthianum* (Sacc. and Magn.) Br. and Cav.] is especially prevalent in the temperate and cool climates. It was extremely severe in 1961 in Cundinamarca, Boyacá, and Antioquia. Rust (*Uromyces phaseoli* var. *typica* Arth.) occurred with moderate severity in Cundinamarca, Boyacá, Antioquia, Valle del Cauca, and Tolima.

The bacterial blights are commonly found each semester (growing season). The common blight [*Xanthomonas phaseoli* (E. F. Smith) Dow.] was severe in Antioquia, Valle del Cauca, and Tolima, but less severe in Boyacá and Cundinamarca.

Four other fungus diseases vary from year to year and even between semesters: powdery mildew (*Erysiphe polygoni* D.C.); gray blotch (*Cercospora vanderysti* P. Henn.); floury blotch (*Ramularia phaseolina* Ptr.); and cercospora leaf spot (*Cercospora canescens* Ell. and Mart.). These diseases were not of great importance in 1961, with the exception of a severe attack of powdery mildew in Cundinamarca.

In addition to common bean mosaic, a complex of undetermined viruses exists in Colombia. This group caused a number of very severe outbreaks in Valle del Cauca, Tolima, and Boyacá during 1961.

During 1958–1960 crosses were made at Tibaitatá, Palmira, and Tulio Ospina, and a total of 10,688 lines in the F_1 to F_8 generations were studied. Of these, 1,375 promising lines were compared in yield trials and 99 of the best were planted in small increase plots at Tulio Ospina and Palmira, where the plots also served as demonstrations for growers.

A great deal of emphasis has been given to regional trials as the final stage in testing improved lines. In the Cauca Valley, 30 lines were grown in 6 representative locations, and in the State of Antioquia, 20 lines.

In 1961 the program studied 5,272 lines: 1,270 at Tibaitatá, 2,500 at Tulio Ospina, and 1,502 at Palmira. From the Tulio Ospina material, 348 lines of string beans were selected from which it is expected that a variety with good yield, disease resistance, and without fiber can be chosen.

The advanced generations of 192 lines were tested in yield trials at Palmira, Tulio Ospina, Tibaitatá, and Duitama. These are to be studied in multiplication plots in 1962, in the hope that at least one at Palmira and another at Tibaitatá can be selected and released.

CULTURAL PRACTICES

The use of better cultural methods to increase production has been given considerable emphasis.

Planting density. Experiments have established that planting in paired rows 30 cms. apart, with 60 cms. between the pairs, increases yield by 18% as compared with the common practice of single rows 60–70 cms. apart. No differences were obtained when the plants were spaced 15, 20, 25, or 30 cms. in the row.

Planting system. Experiments were concluded in 1958 and 1959 which confirmed that planting on ridges is beneficial in the Cauca Valley.

Planting on ridges, demonstration plot, Palmira.

Here periods of abundant rainfall and also periods of prolonged drought are common, and planting on ridges facilitates drainage in wet periods and irrigation in dry ones.

Chemical weed control. Pre-emergence sprays (DNBP) with dosage adjusted in different areas, have given good control of common weeds. The program has adopted this spray and recommends it to farmers.

Fertilization. Studies of the effect of the application of boron to the soil, begun at Palmira in 1957, have shown a loss in yield, contrary to results with other leguminous species. Certain indications of zinc deficiency were observed in other studies with this element, and induced the planning of further investigations. The results thus far for both elements are inconclusive.

In cooperation with the soil program at Palmira, various experiments were planted near Popayán to study the reaction of beans to lime, phosphorus, and magnesium. These may be summarized as follows: highest yields came from P_2O_5 and lime, but the greater part of the effect was due to phosphorus; phosphorus at 100 and 200 kg./ha., the two levels used, were highly significant; treatments with and without lime were significantly different, but there was no difference between levels of 5 and 10 tons of lime; magnesium had no effect on bean yields.

Another cooperative study at Palmira on water requirements in bean cultivation is seeking to throw light on a critical factor in bean production in the Cauca Valley. Preliminary results show that evapotranspiration in beans at this location is approximately 220 mm., the greatest amount occurring between the formation of pods and ripening. Other cooperative studies are being made on the response of beans to applications of calcium, phosphorus, and magnesium, and on the response of beans to applications of calcium and phosphorus at three different levels.

SPECIAL STUDIES

The following basic studies were initiated within the last three years.

"Plot size and number of replications for experiments on beans." This was conducted at Palmira over four semesters, using five varieties, with plots of two, four, six, and eight rows 70 cms. apart, and rows of 4, 6, 8, and 10 m. in length, each plot replicated from two to ten times. The results showed that a plot of two rows, 4 m. long, with four replications, is statistically and economically the most efficient.

"Inheritance of resistance to angular leaf spot." This work is conducted at the Medellín station. Direct and reciprocal crosses were made between two susceptible varieties and a resistant line to study the inheritance of resistance to *Isariopsis griseola*. The F_1, F_2, F_3, and backcrosses were tested by artificial inoculation and natural infection in the field, along with resistant and susceptible parent plants. The findings are to be published in *Agricultura Tropical*.

"Taxonomic classification and description of common weeds which affect bean development in intermediate and cold climates of Antioquia." This study, conducted at the National Faculty of Agronomy, Medellín, includes descriptions of 14 monocotyledonous and 34 dicotyledonous species of weeds collected in bean fields. The results were used for a student's thesis.

"Genetic variability in the bean variety Estrada Rosado, based on physiologic and morphologic characteristics." Estrada Rosado is a local variety which appears to be composed of several genotypes affecting the inheritance of grain size, plant size, and rust resistance. It may be a hybrid segregation in an advanced generation, or a composite variety. It is proposed to separate the genetic components and to correlate grain and plant size with resistance to rust.

"Inheritance of resistance to cercospora leaf spot." This project follows the completed study mentioned previously on the angular leaf spot disease.

"The inheritance of yield and earliness." Begun in 1960. The objective is to determine in early generations what part of the variability is due to environmental causes and what part to heredity. This information will be useful in determining the number of selections advisable in the breeding program, and thus aid in avoiding an excessive number of crosses, which are difficult to make. It was decided to make direct crosses and to use F_3 families proceeding from F_2 self-fertilizations for this study.

"The linkage system in beans." The character selected for this study was the growth type—bush and semi-bush. This study has just been initiated and will be conducted over a period of years.

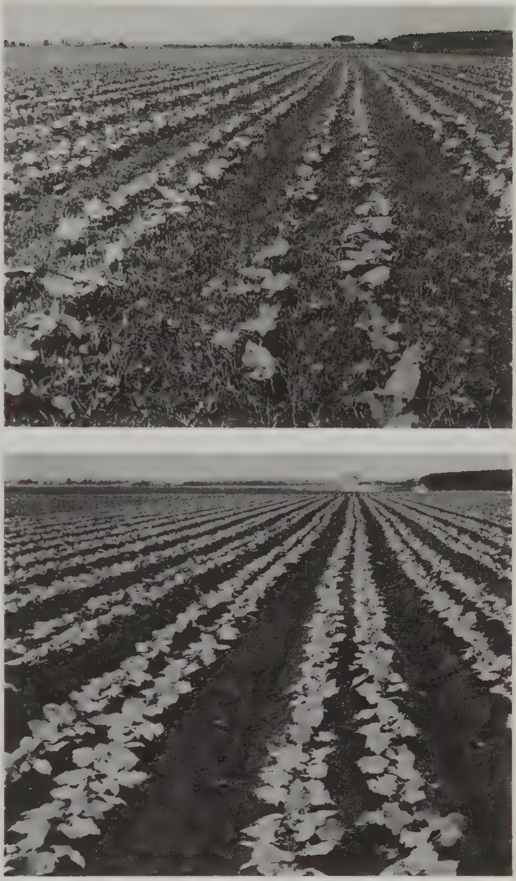
PEAS

Research on peas, a high protein legume widely used in Colombia, is included in the bean program. With their short vegetative period, peas are valuable for rotation with other crops in cold climates. Although work with peas began only recently, two improved varieties have already been released to farmers.

RELEASES

Diacol Boyacá, selected at Tibaitatá from a Swedish collection, has agronomic characters superior to the varieties commonly cultivated in the cold regions of Colombia. The three or four seeds in each pod are smooth, have a cream color, are easy to shell, and may be consumed either fresh or dried. The growth period from germination to harvest is 120 days for fresh peas and 160 for dried. Though a vine type, Diacol Boyacá can be grown without training poles, reaches a height of 120 to 130 cms., and yields 1,600 to 2,000 kg./ha. of dry shelled peas, in comparison with 400 to 1,000 kg. ordinarily produced by local varieties.

Diacol Caldas was selected at Tibaitatá from an Australian collection. It is used as a fresh vegetable only, is a vine type but can be cultivated without poles, reaches a height of 120 to 130 cms., and yields 1,500 to 1,800 kg./ha. of dry shelled peas. The pods are easy to shell, and have seven to eight peas each. When dry, the peas are large, dimpled, and have green and violet spots. Because of its vigor and rapid development, Diacol Caldas can also be used as a green manure crop.



(*Top*) untreated bean plot; (*bottom*) bean plot with pre-emergence application of a weed-killer.

VARIETAL IMPROVEMENT

The pea program has a germ plasm bank of over 330 collections of national and foreign material. These are being studied at Tibaitatá, Surbatá, and La Selva. Earliness, yield, seed quality, and reaction to diseases and insects have been evaluated. The collection contains valuable material for resistance or tolerance to several important diseases.

Approximately 780 lines in F_1 to F_4 were tested prior to 1961. Eight yield trials of the best selections from the collection were conducted at Tibaitatá and Surbatá, using a simple lattice design. Notes were also taken on the reactions to several diseases, including powdery mildew.

In 1961 the germ plasm bank was further increased and 30 outstanding varieties were chosen from which individual selections will be made.

Some 700 lines from crosses made in 1960, and 500 F_1 progenies were planted to obtain varieties which develop early and are resistant to diseases common in the production zones.

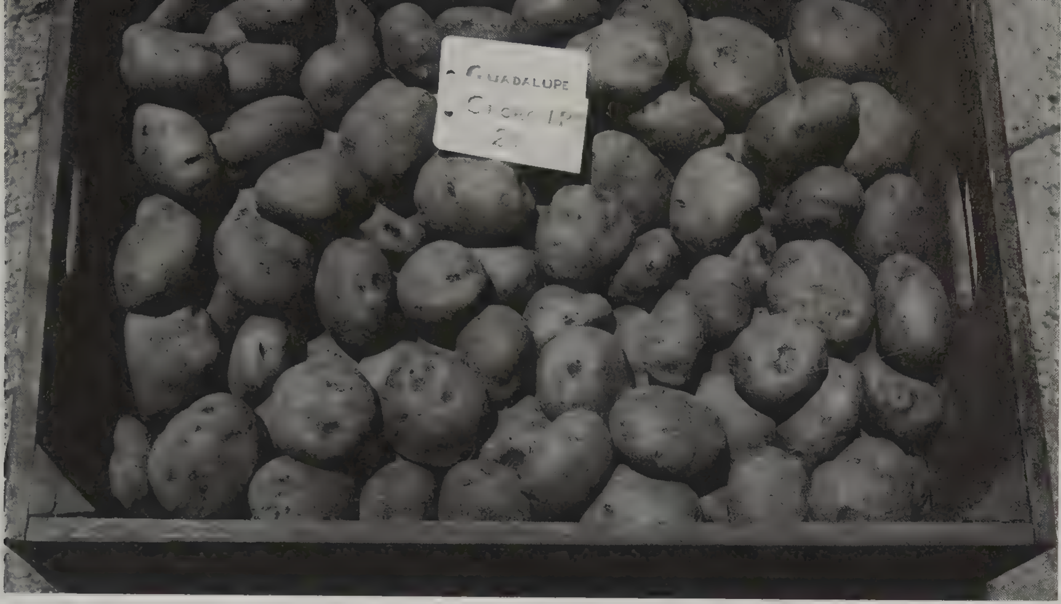
COWPEAS

Research on cowpeas is also included in the bean program. This legume is important in warm climates where it can be rotated with cotton. It is also used for green manure, and as a food crop in some regions of the northern coast.

VARIETAL IMPROVEMENT

Some 160 collections have been studied at Turipaná, Nataima, and Palmira. The best varieties selected and yield-tested in each region have been released to farmers.

At Nataima certain collections from the States of Bolívar and Tolima in Colombia, from Venezuela, and from Bechuanaland in Africa were selected for tolerance to bacterial and virus diseases. At Palmira, the selected variety Vilmorin yields 2,200 kg./ha., the variety U.S. 82 yields 2,100, and Cebra yields 1,700. This production is considered to be outstanding for this region.



Storage studies with sprout inhibitors: tubers treated with 2% chloro-IPC after five months in storage.

Potatoes

In the potato improvement program continued emphasis has been placed on the breeding and selection of new varieties. The newer varieties Diacol Cumbal, Diacol Sumapaz, and Diacol Capiro were planted in regional trials in various parts of the country along with several new hybrids and the commonly grown local varieties. In most regional tests the new ones have been superior in yield and resistance to the late-blight disease, and earlier in maturity than the native varieties. An unseasonal frost reduced yields in the Savannah of Bogotá and Boyacá; even so, the yield of the newer varieties was greater than that of the commonly grown ones.

Two new insect pests were observed which cause severe damage to potatoes in localized areas during the growing season. The larvae of a Noctuidae species caused damage to the foliage and an *Epitrix* species was found infesting the tubers. Although these insects have previously been observed on potatoes they were not known to cause serious damage. The unseasonal frost is believed to have altered the life cycle of these insects, producing the larval stage which caused the damage during the growth period. Normally the larval stage of these insects would not have appeared at this time.

The multiplication of the newer varieties is continuing under the supervision of the Caja Agraria, the agricultural credit bank. While the demand for seed during the past year was greater than the supply, it is hoped that this year's increase of new varieties will meet the demands of the coming season. Because of a lack of trained personnel to produce seed in Antioquia all available seed stock from the Tibaitatá station is being shipped to this region. An agronomist has recently been engaged for training and future work in Antioquia.

Storage facilities for potatoes at Tibaitatá are being developed. It is expected that these will be completed at the same time as the power supply installation for the station and thus permit operation of the equipment. It is anticipated that these storage facilities will provide better and increased capacity for seed production and simultaneously demonstrate the desirability of adequate storage for commercial potato production.

Nine positions have been approved for agronomists in the potato program but at

One of the promising hybrids developed from crosses with *Solanum stoloniferum* Schlechtd.

present only six of the positions are occupied, including an agronomist in training at Tibaitatá. Two of the agronomists are presently studying for the Ph.D. degree at universities in the United States.

VARIETAL IMPROVEMENT

Approximately 95,000 hybrid seedling lines were planted in 1961. These hybrid lines were selected for field resistance to late blight after exposure to natural infection in the field. The collection of 1,300 hybrids selected in previous years was further screened on the basis of yield tests and other agronomic factors, reducing the number to 450 more promising hybrids. Of these 450 hybrids, 22 were selected for preliminary multiplication and regional testing. High yield, early maturity, and resistance to the late-blight disease continue to be the most outstanding characteristics of the new hybrids.

The variety Diacol Monserrate, although demonstrating many advantageous qualities, is highly susceptible to virus diseases. The variety Diacol Sumapaz has many of the desirable characteristics of Diacol Monserrate and in addition is highly resistant to virus diseases. In regional trials Diacol Sumapaz has produced greater yields without application of fungicides than the common varieties with spraying. Diacol Sumapaz also sprouts shortly after harvesting, a desirable characteristic if the grower wishes to plant soon after harvest. Rapid sprouting is undesirable when the tubers are stored for market; however, recent tests have indicated that sprouting can be controlled for a period of five to six months by the use of sprout inhibitors.

Diacol Cumbal, developed for the Nariño region, has consistently produced high yields; however, the late-blight resistance of this variety has not been outstanding. Diacol Sumapaz is also expected to be well adapted to conditions in Nariño, as indicated by recent regional trials.

Diacol Capiro, selected for production in the potato-growing region of Antioquia, has exceeded expectations for acceptance by growers in this region.

Diacol Guadalupe continues to produce high yields, with early maturity and resistance to virus diseases as its major characteristics. This variety has not exhibited as high a degree of resistance to late blight as is desirable.

Several hybrids of the cross *Solanum stoloniferum* × *S. andigenum* are giving excellent results in preliminary trials. One of these, 53-193-3, will probably be released in the near future after further regional testing.

These new varieties give potato growers a greater selection of material with well-adapted, high-yielding, early maturing, disease-resistant characteristics which are distinct advantages over the previously grown varieties.

YIELD TRIALS

In a yield test at Tibaitatá a total of 23 hybrids were compared with the two commonly grown varieties, Tocana Blanca and Tuquerreña. All except three of the hybrids yielded more than Tuquerreña and all except eight yielded more than Tocana Blanca. The lower-yielding hybrids were those selected for other regions of Colombia and were included in this test only for comparison. Sixteen of the hybrids yielded more than either Tocana Blanca or Tuquerreña. Twelve hybrids produced yields significantly greater (5% level) than Tocana Blanca. The varieties Diacol Monserrate, Diacol Guadalupe, Diacol Sumapaz, and Diacol Capiro were in the group with statistically significant increases in yield. The check variety Tocana Blanca produced 28.4 ton/ha. (426 bu./A.) as compared with the highest yielding hybrid, 55-375-1, which produced 72 ton/ha. (980 bu./A.). Diacol Monserrate yielded 39.2 ton/ha. (588 bu./A.), which in past years was considered to be an exceptionally high yield in Colombia. It is evident that yielding ability is one of the factors that can be easily improved in the breeding program and that it is readily expressed if various other cultural practices are adequate.

REGIONAL STATIONS

OBONUCO

The relatively low yields obtained by farmers in this area can be attributed to a combination of many factors, such as inadequate fertilization, small, diseased seed, inadequate control of insects and diseases, and low population density of plants. The average size of farms in this area is small as compared with those in other regions and most of the work on them is done with hand implements and oxen. Any factor that would increase production per unit of area would greatly increase efficiency and productivity per unit of labor expended. Because of the nature of a greater part of the terrain in this region it is difficult to mechanize most of the smaller farms. The potato program at this regional experiment station has been developed with the objective of giving assistance to the small farmer with limited resources as well as to the larger landowners.

The soil program has determined the optimum quality and quantity of fertilizer to be used for potatoes on many of the soil types in this region. Experiments on density of planting and size of seed have indicated that increased yields may be obtained by using seed weighing 50–60 grams, planted at intervals of 25–30 cm. in the row. The insect and disease problems of potatoes in this area are similar to those in the Savannah of Bogotá and the control measures developed at Tibaitatá have been found to be effective in the Nariño region. Extension of these methods to the farmer has been attempted by means of small demonstration plots planted on farms in the region. The plots were planted by personnel of the experiment station in six different areas and included variety trials and demonstrations of improved cultural practices. It was shown that yields of 40–50 ton/ha. (600–750 bu./A.) could be obtained by these methods as compared with maximum yields of 10–15 ton/ha. (150–225 bu./A.) ordinarily obtained by the farmer.

The experiment station produced 120 tons of seed of the improved variety Diacol Cumbal which is being distributed to farmers by the Caja Agraria. Plans are being made to increase the seed production program at the experiment station along with increased facilities for storage and handling of seed.

LA FLORIDA

Emphasis in the region around Popayán continues to be on seed production and selection of varieties adapted to its various climatic conditions. Seed can be produced at the higher elevations in this area, but the lack of trained personnel to manage the seed plots and the difficulty of entering the region because of poor roads, have limited seed production. It was found that seed could be produced at lower elevations but that great care was necessary because of increased insect and disease problems. The brown rot disease caused by *Pseudomonas solanacearum* E. F. Sm. increases in severity with a decrease in elevation. Investigations are under way at Tibaitatá in cooperation with the plant pathology section to develop a variety with resistance or tolerance to the brown rot disease. The planting of potatoes at lower altitudes in Colombia could be greatly extended if control of this disease could be achieved.

LA SELVA

The variety Diacol Monserrate continues to produce an excellent yield in this region but it has not been widely accepted because of its apparent susceptibility to the brown rot disease. Diacol Capiro has been more readily accepted because of its apparent field tolerance to brown rot noted by many farmers. It is hoped that an accurate evaluation of this disease resistance observed by the farmers can be made under experimental conditions in the field. Several other hybrids have also shown promise in yield tests at this station. Disease resistance and market acceptability of the new hybrids have not yet been determined.

The potato work at La Selva is presently conducted by the station director. Plans have been made to increase the work when the agronomist recently engaged for this position terminates his training period.

A long-term rotation study comparing several cropping systems; to simulate farm conditions pasture plots are grazed rather than clipped.

Pasture and Forage Crops

The aim of forage crops and pasture investigation is the improvement of grass and legume productivity leading to improved animal performance. Previous annual reports have described certain phases of the experimentation. This one is a review of the over-all program.

Eleven positions have been approved for this section and at present nine have been filled. Three of the staff have completed the M.S. degree at universities in the United States; two are pursuing this degree and two are working toward the Ph.D. The personnel are located at the following stations: Tibaitatá, Tulio Ospina, Palmira, Nataima, and Turipaná. In addition, work is being done, or has been terminated, at other locations: San Jorge (10,200 feet); Usme (10,000 feet); Guachucal, Savannah of Túquerres (9,300 feet); Obonuco, Pasto (8,600 feet); Paipa (8,500 feet); La Selva, Rionegro (7,000 feet); Manizales (6,700 feet); La Florida, Popayán (5,200 feet); and Villavicencio (1,400 feet).

INTRODUCTIONS

More than 150 grass and legume species have been observed in introduction gardens located at the principal experiment stations and substations. The more promising entries were evaluated at 20 locations ranging from sea level to above 10,000 feet. In many instances the trials comprised 35 to 40 varieties of the better adapted species. The characteristics studied included seedling vigor, tillering, foliage density, forage production, days to flowering, relative seed yield, recuperation after cutting, and persistence or longevity.

The introduction gardens are permanently maintained and new entries are added each year. The constant quest for materials can be profitable and it is not uncommon for an introduction to be moved from the observation garden to regional trials and then directly distributed for farmer use. This has happened in Colombia with pangolagrass (*Digitaria decumbens* Stent.); coastal bermuda [*Cynodon dactylon* (L.) Pers.]; buffelgrass [*Pennisetum ciliare* (L.) Link]; and angleton bluestem [*Andropogon nodosus* (Willem.) Nash]. Two selections of elephantgrass (*Pennisetum purpureum* Schumach.), Merkerón and Costa Rica 534, were recently introduced into Colombia, observed at the Palmira station, placed in several regions for further studies, and are now being rapidly multiplied and distributed by the Ministry of Agriculture and by farmers.

A multitude of productive and long-lived grasses are available for tropical and subtropical conditions, but persistent and high-forage-yielding legumes are uncommon. Those which can be utilized generally do not persist under frequent clipping or heavy grazing nor do they grow well in mixtures with grasses; examples are tropical kudzu (*Pueraria phaseoloides* Benth.); tick-clover (*Desmodium* sp.); hyacinth bean (*Dolichos lablab* L.); velvet bean (*Stizolobium deeringianum* Bort.); pigeon pea [*Cajanus cajan* (L.) Mills.]; Adzuk bean [*Phaseolus angularis* (Willd.) W. F. Wight]; rice bean (*P. calcaratus* Roxb.); blue pea (*Clitoria ternata* L.); butterfly pea (*Centrosema plumieri* Benth.), etc.

A recent introduction, perennial soybean (*Glycine javanica* L.), has exhibited notable promise. It is a vine with dense foliage, has leaves and stems smaller than the common oil or forage soybean, produces an abundance of flowers and seeds, shows considerable drought tolerance, and has persisted for more than two years when grown alone and in mixture with pangolagrass.

MANAGEMENT PRACTICES

A considerable portion of the investigations have involved various aspects of the following subprojects: method and density of seeding, grass-legume mixtures, height and frequency of cutting, use of companion crops in the establishment of pastures, response of pasture crops to fertilization, cutting treatment as related to time and amount of applied fertilizer, irrigation, supplementary forage crops, rotations and management systems, pasture renovation, weed control, and improvement of natural grasslands. All the data obtained from the many experiments comprising the management studies cannot be covered in this report but a few pertinent results can be reviewed.

FERTILIZATION OF PASTURE CROPS

For grass production, the most vitally needed element is nitrogen, as demonstrated by the data in Table 1.

Similar responses were obtained with other grasses. The addition of nitrogen generally did not influence the grasses during the establishment stage of growth, and it was only after several cuts, or about one year, that striking yield increases were obtained. A significant interaction of rate and time of application was observed in this and other experiments. In regard to total yield, with 300 lbs. of nitrogen a greater benefit occurred from delayed dressings of larger quantities than with more frequent use of smaller rates (50 lb./A. or less). In contrast, a topdressing of 100 or 200 lbs. after every cut stimulated

TABLE 1.

Hay yields (ton/A.) and average percentage of protein of pangolagrass harvested in a 12-month period (six cuts). Yields are averages for three years.

N (lb./A.)[a]	N after each cut	N after 2 cuts	N after 3 cuts
0	1.40 (6.10)[b]	1.44 (6.19)	1.43 (6.45)
300	6.10 (6.31)	7.07 (6.50)	8.56 (6.85)
600	14.95 (7.24)	13.70 (7.84)	12.35 (8.54)
1,200	24.20 (10.17)	22.60 (10.69)	20.95 (10.94)

[a] Total N topdressed to six cuts: 1/6 after each cut, 1/3 after two cuts, and 1/2 after three cuts.

[b] Figures in parentheses are average percentages of protein per cut.

greater production than double or triple these amounts after two and three cuts, respectively. The more frequent application resulted in more uniform plant growth as compared with the tremendous fluctuation encountered in the more prolonged treatments. For instance, yields exceeded 3.0 ton/ha. of hay in the harvest following 200 lbs. of applied nitrogen but fell to less than 0.5 ton in the subsequent harvest without nitrogen. In general, increased increments of nitrogen resulted in a higher protein content of the forage and in a higher recovery of the total nitrogen applied. In some instances up to 80% was recovered in the cut forage but usually the figure was nearer 50% or 60%.

On some soil series a notable response to phosphate and limestone was obtained and in some instances the procurement of a legume stand depended on the addition of one or both substances. This has been especially true for alfalfa. With soils previously cropped and well-fertilized no benefit has been derived from phosphorus or calcium treatment. This has been demonstrated in a number of rotation experiments. As a rule, no beneficial effect of potash has been noted for the establishment of pasture crops, but after several harvests a marked difference in alfalfa yields and stands existed for levels of potassium. This result can be expected when it is realized that more than 400 lb./A. of potash may be removed annually by the alfalfa (seven to nine cuts).

METHOD AND DENSITY OF SEEDING

Results from several trials with cool climate grasses and legumes have demonstrated that annual and perennial ryegrasses, because of their aggressiveness in some regions, should be sown in rows 18 to 24 inches apart, the associated legumes being broadcast. Other grass-legume combinations may be seeded together. These data also revealed that heavy seeding rates are unnecessary, 10 to 15 lb./A. of grass alone or 18 to 22 of a grass-legume mixture being sufficient.

The preferred distance between rows when planting forage sorghums or sudangrass was found to be 1 or 2 feet in comparison with a spacing of 3 feet and broadcast sowings, as based on forage yields. In addition, 10 lb./A. of seed was more satisfactory than 5, 20, and 30 lbs.

TABLE 2.

Forage yields (lb./A.) per harvest of pigeon pea as influenced by height of plant when cut and cutting level.[a]

Height of plant when cut	Cutting level (no. of cuts)		
	Ground level	6 inches	12 inches
20 inches	1,270 (1)	1,330 (7)	1,260 (7)
40 inches	1,550 (1)	4,360 (3)	4,820 (4)
60 inches	4,580 (1)	4,980 (3)	5,520 (3)

[a] Yield differences were significant for height of plant when cut and for cutting level.

HEIGHT AND FREQUENCY OF CUTTING

Information obtained from various trials with cool and warm season pasture crops substantiated data from other investigators that delayed harvest interval results in higher forage yields, but as maturity approaches the quality declines. Production varied considerably and in direct relation to soil moisture; thus, a predetermined interval of harvest probably is not a valid evaluation for both rainy and dry seasons.

Trials at Tulio Ospina and Palmira showed that certain legumes, such as *Phaseolus calcaratus*, *Desmodium intortum*, *Glycine javanica*, *Cajanus cajan*, and *Dolichos lablab*, survived several cuts when harvested at the early flowering stage; *Calopogonium mucunoides* and *Stizolobium deeringianum* did not. Fewer plants of all species persisted when cut with green pods or mature seeds. The height of plant when cut, and cutting level above the ground, influenced the forage yields and number of harvests of pigeon pea (Table 2). This is a species that could be used as a green chop legume, for ensilage in mixture with grasses, or grazed.

SUPPLEMENTARY FORAGE CROPS

Oats are the most appropriate soiling and silage crop for elevations above 6,000 feet. Up to 30 and 40 ton/A. of fresh weight have been harvested with cuts made at full flower or the soft dough stage, four months after sowing. Yields were 4 to 6 ton/A. of green material and protein content was 18% to 20% (dry matter basis) when the plants were cut after reaching a height of 10 to 12 inches; an aftermath harvest at the soft dough stage produced 15 to 20 tons and resulted in a reduction to 6% or 8% protein.

A number of warm climate and subtropical grasses may be utilized for green chop and silage at the lower elevations. These are forage sorghum, sudangrass, elephantgrass, Guatemala, guineagrass, pará, Imperial, and sugar cane (upper leaves and growing tips, and a forage selection). In one experiment, forage sorghum yielded 50 ton/A. of fresh weight within two months from the planting date. Subsequent harvests varied from 15 to 30 tons, depending on soil moisture and plant population. Although plant longevity is in part dependent on genotype, available water was also important. One planting at Palmira was cut 22 times before being destroyed. Elephantgrass also produced as much as 50 ton/A. (fresh weight) per cut under favorable conditions of soil fertility and moisture. About six cuts can be made per year.

GRASS AND LEGUME BREEDING

The main objective in the improvement of pasture crops through breeding and selection is the search for lines or selections with high forage yield potential, resistance or tolerance to diseases, good seed-yielding ability (with certain species), and plant longevity or persistence. Wide phenotypic variation exists within some species and among plants of some varieties. Thus, through mass selection rapid improvement can be made. For some species it is considered worthwhile to utilize several methods of improvement.

COOL CLIMATE SPECIES

Ryegrass (*Lolium multiflorum* Lam.). The improvement program has been oriented toward the selection of clones which are persistent, even though the species is considered primarily an annual in many parts of the world. Attention was also given to forage production, rust tolerance, and seed yield of

Among those being tested in the search for a tropical legume are (*a*) tropical kudzu, (*b*) alfalfa, and (*c*) *Clitoria* sp. in mixture with pangolagrass. The most promising, however, is perennial soybean shown in background.

the original clones. The progeny tests of 200 clones were terminated during the past year and the results will be utilized to select about 10% of the plants for recombination into synthetic constituents. In addition, 50 single plants from 50 introductions of annual and perennial ryegrasses were established for evaluation of the characteristics noted above.

Rescuegrass (*Bromus cartharticus* Vahl.). From a single-plant nursery of 6,000 entries, 150 clones were chosen on the basis of forage growth and high, intermediate, and low seed production. The parental clones and 5 progeny rows, with 20 plants in each row, have been established. From these progenies a number of plants are to be chosen for a study of methods of improvement. Also, seeds from lines with high forage yield and good seed production will be bulked for comparative trials with commercial strains.

Orchardgrass (*Dactylis glomerata* L.). This species is frequently included in pasture mixtures at the higher elevations, above 6,500 feet. Plant development is slow during the early growth stages, but afterwards forage yields equal, or may exceed, those of ryegrass, and the plants persist for many years. Individually spaced plants from 15 varieties are being evaluated at Tibaitatá for forage growth, seed yield, disease tolerance, recuperation after cutting, and persistence. This information will provide the basis for selection of material to be included in the improvement program.

Birdsfoot trefoil (*Lotus corniculatus* L.). Results from varietal trials have demonstrated that this species is more tolerant to drought than any other legume tested. Only one variety, San Gabriel, from Brazil, produced sufficient forage to justify further investigation. Among single plants, wide variation was noted for plant extension, height of forage, foliage density, forage production, flowering and seed development, and aftermath growth. Seeds were harvested from the plants with these characteristics and another nursery of single plants has been established. It is anticipated that after several cycles of recurrent selection more suitable strains can be developed, especially in regard to forage yield, seed production, and plant longevity.

White clover (*Trifolium repens* L.). From a nursery of 10,000 single plants, 80 clones were chosen for good forage growth, uniform seed production, and field tolerance to stolon and foliage diseases. In collaboration with the plant pathology program these have been inoculated in the laboratory with *Sclerotinia trifoliorum* Eriks., the causal agent of the most damaging root and stolon disease. Seven clones showed resistance to the disease; these are being recombined for recurrent selection and further inoculation of progenies.

Red clover (*Trifolium pratense* L.). The method of improvement follows that for white clover in that 80 clones were chosen from a source nursery of 8,000 plants. The selected plants had good forage yield and field tolerance to diseases but varied in habit of growth and seed development. If clones are found to be resistant to laboratory inoculations with *Sclerotinia trifoliorum*, they will be recombined for subsequent selection among progenies and for inoculation studies.

WARM CLIMATE SPECIES

Forage sorghum (*Sorghum vulgare* Pers.). About 15 years ago several strains were introduced from the United States and planted at Palmira. Two lines (M.N. 1045 and Canal Point, without a recorded number) flowered simultaneously and became mixed. The derivative from these produced as much forage as any recently introduced variety. Inbred lines were developed and about 2,000 carried into F_6. Recombinations were made in F_2 and F_6 and about 50 are ready for testing. Many of the inbreds have high forage yields, good seed production, do not lodge, and show high tolerance to foliage diseases.

Imperialgrass [*Axonopus scoparius* (Fluegge) Hitch.]. Gummosis, a bacterial disease, has brought about the destruction of many plantations and threatens others. In an endeavor to find material with tolerance or resistance to the disease, a large number of clones were collected from various parts of the country. After laboratory and field inoculations with suspensions of the disease organisms, made in collaboration with the plant pathology program, two clones have shown high resistance and have been placed in regional tests.

It was found that by placing seeds on a sand-vermiculite mixture, and under glass, a high percentage of germination could be obtained from some clones. The seedlings should provide a wider range of variability if the seeds arise sexually and not by apomixis, as does occur in this genus. Studies have been initiated to determine the means of seed production.

SPECIAL PROBLEMS OF PASTURE CROPS

This phase of the program relates to such studies as seedling or young plant vigor, influence of photoperiod, characterization of growth types of clovers, grass and legume diseases surveyed in collaboration with the plant pathology program, identification and prevalence of legume pollinators made in collaboration with the entomology program, economic aspects of pasture production, and grasses for lawns, golf greens, etc.

RED CLOVER PLANT TYPES

Results from varietal tests of red clover show that wide variation exists for habit of plant growth, forage yield, flowering and seed set, and plant persistency. It was observed that varieties which had been developed above 50° north latitude did not produce flowering plants, whereas those from the more southern regions produced flowers in relation to the decreasing latitude. Single plants can be characterized according to growth habit and placed into five categories: type I being a rosetted plant with no floral stems and type V having no rosette but many erect floral stems, with profuse flowering and seed set. Types II, III, and IV are intermediates between the other two.

Varieties from above 50° north latitude had all plants of type I, varieties from 40° ranged from I to V and approaching a normal curve, varieties from 30° had a high percentage of IV and V, and those from old pastures in Colombia over 90% of type V. This is photoperiod response, and because of the rather uniform 12 hours of daylight under Colombian conditions, the plant growth habit does not change. Thus, shifts in type can be detected when they are caused by seed production in different regions. About 100 seed lots of three varieties—Kenland, Dollard, and Tammisto—were obtained from the U.S. Department of Agriculture. Some of these came from seeds harvested in the same locality for a number of generations and others from different seed-producing areas. Randomly selected seedlings have been transplanted to the field at Tibaitatá for characterization of type.

Preliminary studies with types I, III, and V showed that under normal day-length (12 hours) the flowering pattern corresponded to that described above. With a day extended to 18 hours by 6 hours of artificial illumination, the plants of all types flowered profusely and produced high quantities of seeds, and types could not be distinguished. When day-length was reduced to 12 hours, the plants reverted to their original habit of growth.

GRAZING TRIALS

The grazing and feeding trials are collaborative with the sections working to improve animal production. In general, the agronomists aid in planning the grazing experiments, in the supervision of pasture establishment and maintenance, and in the estimation of carrying capacity (number of animals per unit area). The agronomists are directly responsible for obtaining the forage yields by taking samples from pastures or cages, determining botanical composition, and preparing the forage samples for moisture calculations and chemical analyses. The animal husbandmen aid in some of these phases and are directly responsible for animal care and maintenance, recording animal weights, and calculating production of total digestible nutrients.

In collaboration with the beef cattle section at Palmira, a grazing trial has been completed in which four grasses—pará (*Panicum purpurascens* Raddi), puntero (*Hyparrhenia rufa*

Several new selections of elephantgrass are being increased and distributed, among them Merkerón, Merker, and Costa Rica 534.

Nees), pangola, and guineagrass (*Panicum maximum* Jacq.)—were grazed with steers. Data obtained for 196 days without irrigation and without fertilizer and for 196 days with supplemental water and applications of 75 lb./A. of nitrogen after 56, 112, and 168 days showed the following rates of daily gain per animal: puntero: 1.52 and 1.6 lbs.; pará: 1.34 and 1.52; pangola: 1.0 and 1.6; and guinea: 1.17 and 1.25, respectively, for the two periods. These figures are estimates of forage quality which did not differ greatly for some grasses. Considerable difference did occur for forage quantity in that carrying capacity was doubled when water and nitrogen were used.

In collaboration with the dairy section at Tibaitatá, two mixtures, (1) kikuyu (*Pennisetum clandestinum* Hochst.) and white clover and (2) ryegrass, orchardgrass, and red and white clovers, were grazed with lactating dairy cows. No irrigation was provided. The kikuyu-white clover combination gave a higher carrying capacity (quantity of forage), 1.05 animals per acre as compared with 0.308 for the other mixture. Milk production per animal (quality of forage) was greater for the ryegrass-orchardgrass-clover pasture, being 32.3 lbs. per day as compared with 30.1 lbs. for the kikuyu-clover pasture.

SEED PRODUCTION

Colombia imports all seeds of cool climate grasses and legumes and no seed standards have been defined. As a consequence, the farmer often cannot buy good-quality seeds. Several reasons exist for the lack of seed production in Colombia: (1) no specific varieties have been developed; (2) seed yields of the imported varieties may be nil, low, or very erratic; (3) quality of locally harvested seed is very poor; (4) experience in seed production, harvest, processing, and distribution has not been attained; and (5) natural selection occurs for plants which give high seed yield but which are stemmy and low in forage production.

The seeds of warm climate grasses are locally grown but are of poor quality and have extremely low germination. In many instances the viable seed of such grasses as guinea, puntero, and molassesgrass (*Melinis minutiflora*) may not exceed 1%. Information is needed about times and methods of harvesting and processing procedures.

Preliminary studies have been initiated at Palmira to determine the time and sequence of flowering and seed development of certain grasses. One trial was conducted with individually spaced plants; the results showed that floral development may be continuous under such conditions. Further studies are planned with solid sown stands and with the use of irrigation and fertilizer treatments, in an attempt to effect a more uniform but periodic formation of flowers and seeds.

Micro-Kjeldahl apparatus in the Tibaitatá laboratory.

Soil Science

The work of the soil science program is divided into four main projects: fertilizer usage, rotation and other soil management systems, chemical and physical characteristics of soil as they relate to crop response, and soil-water-plant relationships. During 1961 experiments under one or several of these headings were carried out by agronomists working at six experiment stations and on private farms in surrounding areas. Highlights of some of this work are summarized in the following sections.

Fertilizer Usage

The decision was made in early 1961 to focus attention in this project on the fertilizer needs of small grains. Previous data had shown that a very high proportion of the soils on which wheat and barley are grown are seriously deficient in phosphorus. An evaluation of existing data led to the conclusion that further clarification of this problem would represent one of the more valuable contributions which the soil program could make in the coming two or three years.

In accordance with this decision a total of 32 separate experiments were planted, principally on private farms in Cundinamarca, Boyacá, and Nariño. Improved grain yields due to phosphorus fertilization have been obtained, almost without exception. The principal results of 14 of these tests are shown in Table 1. Individual tests yielded as much as 5 ton/ha. of grain under optimum conditions.

Soil samples from these fields are presently being analyzed for available phosphorus by six different extraction procedures with a view to developing techniques of predicting responses under field conditions. It appears that economic fertilizer applications will be 150 kg./ha. of P_2O_5 in a great many of the important soils of the cereal-growing areas. Much smaller amounts of nitrogen and potassium, perhaps 30 to 50 kg./ha., may be sufficient.

The need for rather large numbers of field tests at widely scattered sites has been amply demonstrated in fertilizer usage studies of this type. In the past the development of this project by the DIA soil program has been seriously hampered by the problem of obtaining labor at off-station sites. Equipment is now being developed at Tibaitatá for machine planting of small-grain experiments and the necessary transportation facilities have been obtained. This should greatly increase the number and precision of field experiments.

TABLE 1.

Principal responses of wheat and barley in 14 fertilizer tests in Cundinamarca and Boyacá. (Yields in kg./ha.)

	Fertilizer applied			
Crop	Unfertilized check	Nitrogen only	Phosphorus only	Nitrogen and phosphorus
Wheat	2,172	2,380	3,048	3,187
Barley	1,906	1,961	2,327	2,642

Other tests under this project were carried out with corn, soybeans, rice, and potatoes, but on a much more limited scale. Among the more interesting results were data concerning rates and timing of nitrogen fertilization of rice at the Nataima station in the Tolima Valley. The data indicate nitrogen to be severely limiting at this station. Yields were increased 1 to 1.5 ton/ha. by the application of up to 160 kg. of nitrogen. Split fertilizer applications were necessary in order to obtain maximum nitrogen response.

CROP ROTATION STUDIES

Several experiments concerning the fertilization of a potato-wheat-pasture rotation were brought to a close in 1961. The results of these experiments emphasize the benefit of phosphorus residues from a properly fertilized potato crop. It is clear that the phosphorus needs of wheat are considerably reduced following a well-fertilized potato crop, and it is probable on many soils that several cycles of phosphorus applied to potatoes will leave residues adequate to meet the needs of the wheat and pasture which follow.

Various experiments in the past several years have indicated that good yields may be obtained in the rotation potatoes-wheat-pasture. Other tests with continuous potatoes and continuous wheat have shown a strong tendency for yields to decline under a single-crop system. Increased incidence of diseases as well as nutritional problems are clearly factors in this decline. Still other observations lead to the suspicion that the simple rotation of potatoes-small grains leads to lower yields, again with increased disease incidence as a probable factor. During 1961 a new experiment was established at Tibaitatá to obtain some direct data concerning the relative effects of these rotations. The treatments included will permit some measure of the role of declining levels of plant nutrients in these effects, particularly as regards nitrogen and phosphorus. In order to obtain a more valid measure of the true effect of pastures, these plots are being grazed rather than clipped. Soil and plant analyses will provide a further gauge of the effects of these rotations on other aspects of nutrition. Observations on disease incidence will be important in evaluating these rotations.

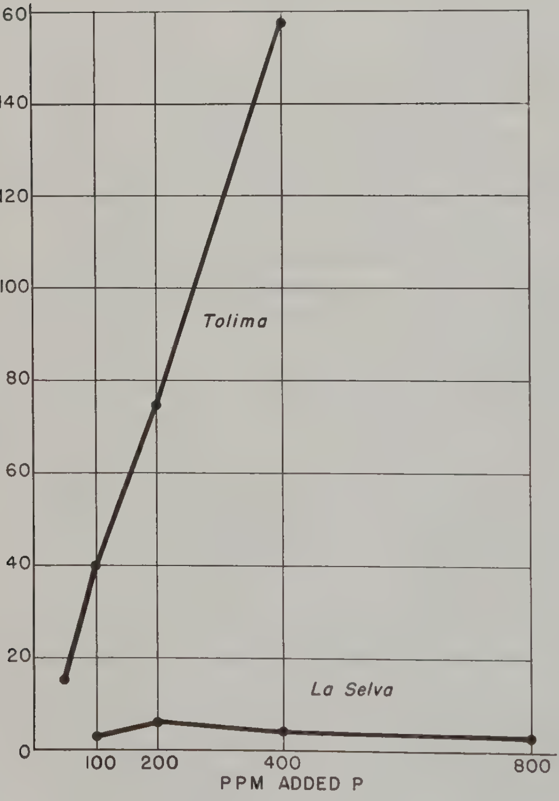
At Palmira, corn is the principal crop in rotation studies. It is grown in continuous culture and in various combinations with soybeans and alfalfa. Results to date have demonstrated clearly the benefit of a legume in rotation with corn. During six seasons the average yield of corn under continuous cropping has been 4.03 ton/ha. In the rotation soybeans-corn, yields of corn have averaged 5.37 ton/ha. In the rotation soybeans-corn-corn, yields have averaged 4.66 tons and under alfalfa (four semesters)-corn-corn the average has been 4.94 tons. Responses to nitrogen under the various rotations demonstrate that a major part of the legume benefit is due to a better nitrogen status. These data are supported by laboratory analyses which indicate higher levels of nitrate in the soil following the legume crop.

The effect of a legume in rotation with corn has been rather short-lived in the Palmira experiment. Over the four semesters in which direct comparisons have been possible, the first corn crop after soybeans has averaged 4.89 ton/ha. The second crop after soybeans has averaged 3.42 tons. In the alfalfa-corn rotation, the first corn crop after alfalfa has averaged 5.54 tons and the second crop 3.82

tons. Over this same period yields under continuous corn have averaged 3.08 ton/ha.

Laboratory and Greenhouse Studies

Additional data were obtained in 1961 concerning the value of several laboratory methods of extracting phosphorus from representative Colombian soils. For this study 46 soil samples were collected throughout the country. Barley, the test crop, was grown in a greenhouse experiment with and without added phosphorus. Growth increases were obtained on a great many of these soils as a result of the added phosphorus, and the relative increase was used as a basis for comparing the efficiency of various chemical extraction procedures. Six different procedures used in other parts of the world were compared (Table 2). It will be noted that most of the procedures gave some degree of correlation. In all cases where plant growth indicated a poor phosphorus status the laboratory methods likewise showed the soils to be poorer in phosphorus. Certain testing procedures gave closer correlations than others, however. The methods referred to as Bray 2, and N.C. (developed by the North Carolina Soil Testing Laboratory) appear to be the most promising for general use in Colombia. With these procedures the soils with response indices of less than 25% gave values of less than one-sixth as much extractable phosphorus as soils with relative yield indices of 75% or more. Further comparisons of these procedures with yield data obtained in field experiments should result in the adoption of techniques for advising farmers on fertilizer requirements.



Phosphorus fixation in two Colombian soils: "La Selva" shows extreme fixation of added phosphorus, "Tolima" appreciable increase in available phosphorus after application of this element.

Ten of the soils included in these correlation studies were subjected to a much more detailed analysis of physical and chemical properties. Of particular interest were data relating to their phosphorus-fixing capacities. Varying amounts of phosphorus were added to samples of the soil and after equilibration they were extracted by the N.C. procedure for measuring available phosphorus. It was found that soils of the cool climate of Colombia had in general a very strong fixing capacity for phosphorus. One soil, from near Rionegro in Antioquia, fixed all of the added phosphorus (800 ppm). By comparison, a soil from the Tolima Valley contained more than ten times as much available phosphorus following the addition of 400 ppm phosphorus as it had contained in the original state. Mineralogical analyses showed the soil from Antioquia to contain appreciable amounts of allophane, a hydrous aluminum silicate, which probably accounted for much of this fixation. These data point to the need for investigating band placement systems of phosphorus application which will tend to reduce contact between soil and fertilizer and hence to delay the fixation of this nutrient in unavailable forms.

TABLE 2.

Relative yield of barley and P_2O_5 extracted (kg./ha.) by several procedures.

Relative yield (%)	Extraction procedure					
	Bingham	Olsen	Bray 1	Bray 2	N.C.	Purdue
<25	0.28	35.6	17.3	36.0	26.5	203.8
25–50	0.38	49.1	26.1	56.4	39.6	282.1
50–75	0.45	78.5	44.1	131.6	108.0	661.3
>75	0.96	112.6	101.2	264.4	195.7	824.4

The value of leaf and petiole analyses as a gauge of the nutritional status of potatoes is being investigated. Samples of plant tissues have been collected in field experiments in which yield responses to nitrogen, phosphorus, and potassium have been obtained. These tissues have been analyzed for total nitrogen, phosphorus, and potassium, and for nitrates and soluble phosphates. Nitrate and phosphate levels in petioles seem to identify deficiency conditions more clearly than do total nutrient levels in the leaf blades. Some of these data are shown in Table 3.

The levels of nitrate and phosphate which are associated with situations of deficiency or adequacy are quite similar to those reported in other parts of the world. If verified, these critical levels will be used to assay the nutritional status of commercial potato plantings on a survey basis. Such data will be useful in determining the adequacy of present fertilizer practices and will serve as a guide in further field experimentation.

SOIL-WATER-PLANT RELATIONSHIPS

During 1961 facilities for irrigation studies were substantially improved. At Palmira a soil physics laboratory was established and equipped with the necessary facilities for mechanical analyses and the determination of moisture retention characteristics of soils. The laboratory will be prepared to accept samples from all branches of the soil program.

Irrigation equipment for field experiments has been obtained for the Palmira and Obonuco stations. Experiments have been established at Palmira to study some of the interactions between water supply, plant population, and nitrogen fertilization in corn yields. At Obonuco new experiments include the measurement of irrigation effects in the

TABLE 3.

Nitrate and phosphate content of petioles of potatoes and total N and P of leaf blades as related to fertilizer treatments.

P_2O_5 applied (kg./ha.)	Phosphate-P (ppm)	Total-P (%)	Nitrogen applied (kg./ha.)	Nitrate-N (ppm)	Total-N (%)
0	1,098	0.33	0	5,507	5.15
160	1,905	0.38	40	9,019	5.70

maintenance of legume-grass mixtures under clipping and under grazing. The new equipment installed at this station will make it possible to maintain closer control over soil moisture than could be achieved in experiments established previously with potatoes and alfalfa.

Irrigation studies are urgently needed in the Savannah of Bogotá and surrounding areas. During 1961 no such tests could be carried out at Tibaitatá because of water shortages during critical periods. Attempts to carry out irrigation experiments on a nearby farm were not successful owing to the lack of adequate equipment and labor for day-to-day control. It is hoped that in the near future these difficulties will be resolved, although it may prove necessary to drill one or more deep wells at Tibaitatá.

LABORATORY FACILITIES

During 1961 the reorganization of laboratories of the soil program went forward essentially as planned. All routine plant analyses are presently being run at Tibaitatá and routine soil analyses at Palmira. In spite of troublesome water and electricity shortages at Tibaitatá it has been possible to more than double the output of this laboratory.

At Palmira the effects of basic changes in laboratory facilities should be realized in the near future. In addition to the physics laboratory mentioned above, the chemistry laboratory has been rewired and a more adequate water supply provided. New benches have been installed and an old gas-heated Kjeldahl apparatus has been converted to electrical operation.

Four of the more than 5,000 lines of oats tested in 1961 for reaction to a new race of stem rust.

Plant Pathology

The plant pathology program in Colombia has some of the finest facilities and equipment in Latin America. At Tibaitatá the following are available: an excellent laboratory, facilities for field work, three plant growth cabinets, adequate greenhouse space in which temperature is partially regulated, and a headhouse with all the services needed to complement the greenhouse such as storage space for soil, steam generator and autoclave, and good working space. The sections at Palmira and Tulio Ospina have modest but adequate laboratory and greenhouse facilities which can be expanded when additional personnel are added. As regards personnel, 6 of the 11 authorized positions are filled. Two pathologists are studying in the United States, one for the Ph.D. degree and the other for the M.S. degree. The two Colombian pathologists at Tibaitatá both have Ph.D. degrees.

WHEAT, BARLEY, AND OATS

Studies made in the plant growth cabinets in which light, temperature, and to some degree humidity can be controlled, have given valuable information on the identification of races of stem rust of wheat and oats. In one such study, 21 distinct collections of oat stem rust (*Puccinia graminis* var. *avenae*) and wheat stem rust (*P. g.* var. *tritici*) were studied simultaneously at three different temperatures (65°F., 75°F., and 85°F.) in the growth cabinets and in five different locations in the greenhouse equipped with Floral Breeze units which cool by water evaporation. The results of this study have demonstrated that the reactions given by races incubated in the greenhouse cooled by the Floral Breeze units were the same as those in the growth cabinets at 65°F. This information means that rust race identifications made in the cooled greenhouses can be used with a high degree of confidence, and rust work can therefore be continued on a much larger scale with reliable results.

Physiologic race identifications of stem rust of wheat were continued in 1961, primarily in the greenhouses with Floral Breeze units. Of 522 collections studied, 7 races were identified. Race 28, the race group 6-178, and a new race comprised 38.3%, 38.1%, and 19.9%, respectively, of the collections identified. The remaining 3.7% included the races 15B, 26, 90, and 178. None of the collections studied was capable of attacking the varieties Bonza and Nariño.

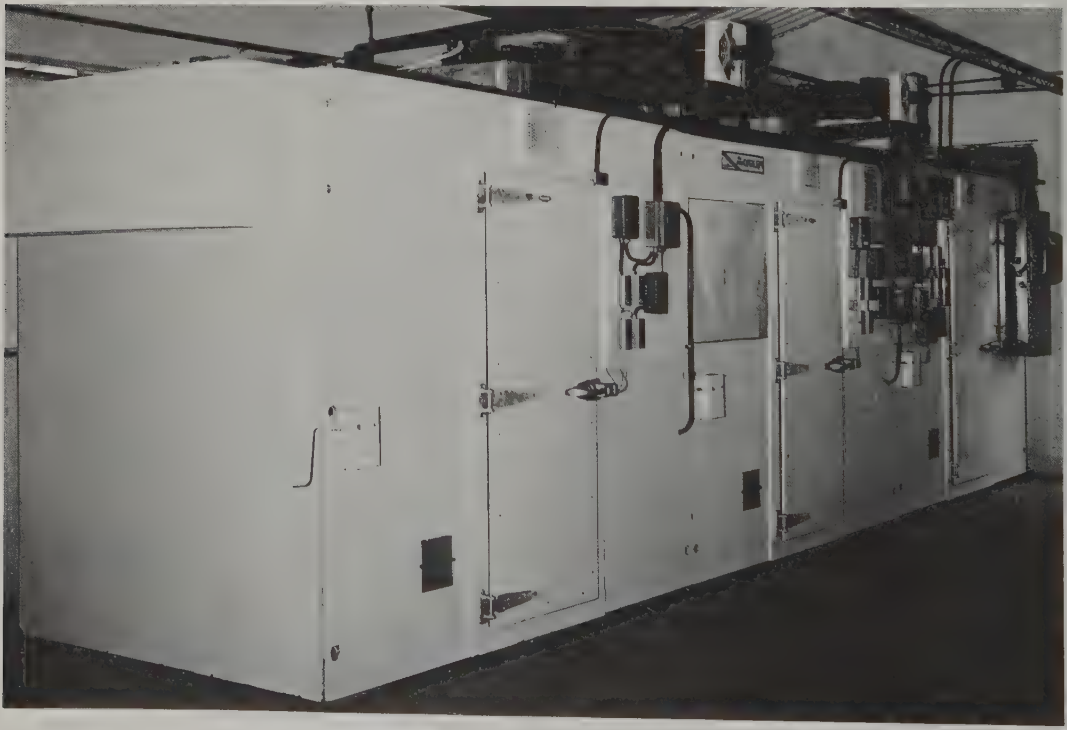
Stem rust of oats continues to be a most threatening problem in Colombia. A total of 726 collections was studied at Tibaitatá, and 6 races and 22 subraces were identified from this material. Race 13 comprised 30% of the collections; race 6, 19.7%; race 12, 17.0%; race 4, 16.0%; race 3, 11%; and race 7, 6.3%. The subrace 6C is the most virulent identified to date. It is capable of attacking all known genes for resistance at temperatures from 60° to 85°F.

In greenhouses cooled by Floral Breeze units, 5,000 varieties or lines from the world oat collection of the U.S.D.A. and 400 oat lines from the Colombian oat breeding program were tested for their resistance to the subrace 6C. In the seedling stage all were susceptible except a few plants of two varieties from Yugoslavia. These, unfortunately, were susceptible when reinoculated at a later stage of growth. This search for sources of resistance to oat stem rust, with its serious implications for oat production in Colombia and elsewhere, will continue.

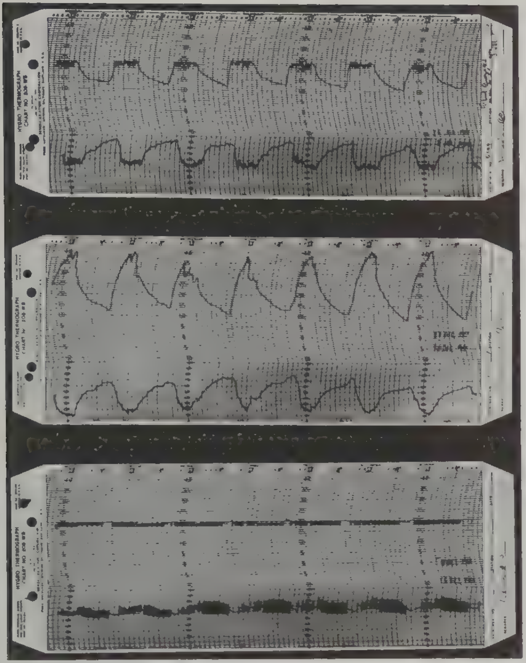
POTATOES

The plant pathologist who is studying the nature of partial resistance of potatoes to *Phytophthora infestans* spent five months in the United States and Mexico working on this subject. With the potato section of the Mexican Agricultural Program, she evaluated the partial resistance of Colombian potato clones under Mexican conditions. Several Colombian clones of *Solanum phureja* exhibited a very high degree of partial resistance to late blight in Mexico.

Using testing techniques developed from basic studies on the nature of partial resistance, several thousand potato seedlings from true seed were tested in the greenhouse for partial resistance. The survivors from these tests are presently being compared with similar uninoculated material, screened under field conditions, to evaluate the efficiency of the greenhouse test. If effective, the test would considerably reduce the labor and amount of land involved in testing hybrid seedlings.



Growth cabinets at Tibaitatá in which temperature, light, and humidity are controlled.



Temperature and humidity in: *top*, greenhouse with Floral Breeze unit; *middle*, greenhouse without temperature control; *bottom*, growth cabinet.

FORAGE CROPS

Work on the disease gummosis of Imperial and micay grass, caused by *Xanthomonas axonoperis*, was continued at Tulio Ospina. Clones previously selected as resistant to the disease are being multiplied for distribution, and demonstration plots with resistant clones have been planted at several locations. An experiment designed to determine the role of the machete as an agent of transmission of the disease gave striking results. Machetes which had previously cut diseased plants transmitted the disease to almost 100% of healthy plants cut subsequently with the same machete. Transmission of the disease was easily prevented by sterilizing the machete in formaldehyde. The use of resistant clones and an effective sanitation program would eliminate this important gummosis disease of grass from Colombia. An effective extension program is necessary to provide these results to growers and thus obtain adequate control.

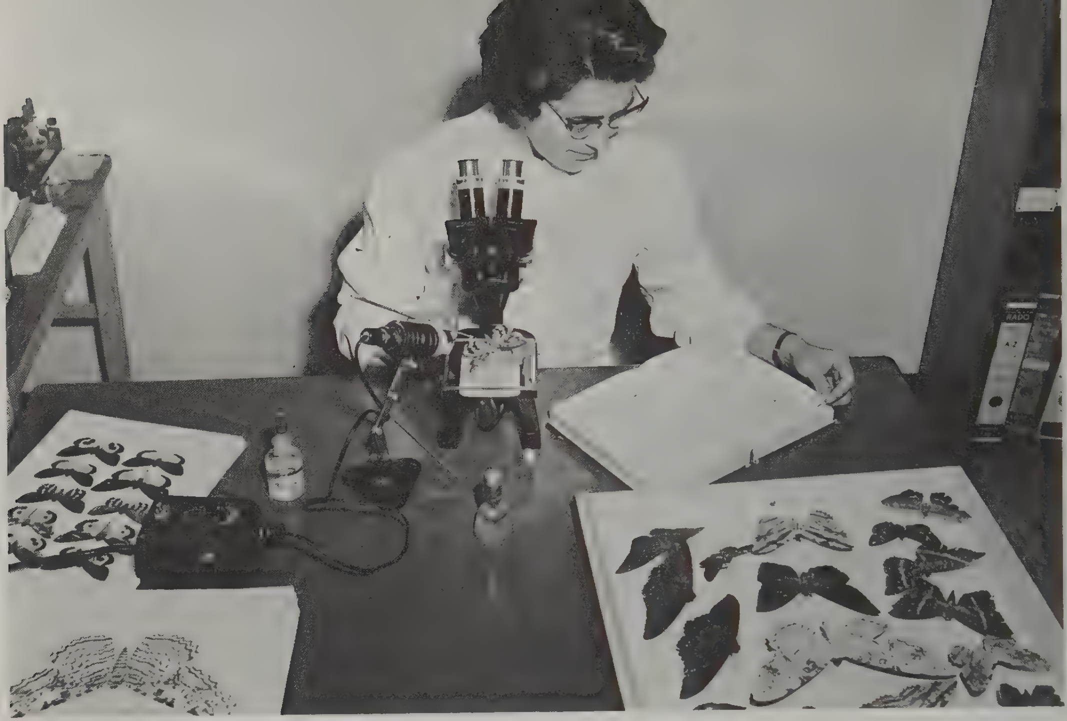
OTHER STUDIES

The plant pathologist at Palmira has continued studies on hoja blanca of rice and ratoon stunting of sugar cane, confirming previously reported results.

Tests were continued on the resistance of corn lines to stalk and ear rots caused by *Diplodia zeae* and *Fusarium* species and to *Helminthosporium turcicum* at Palmira and Tulio Ospina.

An extension pathologist from the section of plant sanitation of the Colombian Ministry of Agriculture has been in training at Tibaitatá during the period of this report. During the year he received 136 diseased samples representing 55 different species and identified 106 disease-causing agents on them.

The greenhouse at Palmira was equipped with a Floral Breeze unit which has controlled temperatures very well.



Entomology

The objective of the entomology program is to determine practical controls for insects that affect those crops and livestock which are of economic importance in Colombia. The work completed by the entomologists during the past year was largely a continuation of earlier studies.

SURVEY OF INSECTS

The reference collection of pests was increased during the year by the addition of new specimens and by the return of material sent to specialists for identification. Of special interest was the arrival of a collection of ticks of livestock that were identified by a taxonomist.

Special collections of pests of vegetable crops and of *Cicadulina*, the vector of the enanismo disease of barley, and related species were made during the year; these will be entered into the general collection when they have been identified.

The insect survey revealed two pests of forage crops which were severe during the year: Rhodesgrass scale, *Antonina graminis* (Maskell), and an unidentified cecidomyiid that attacks sorghums. Studies of the control of both were started late in the year. Another pest that appears to be threatening in the Pasto area is a dipterous miner of seedling beans, probably *Hylemia cilicrura* (Rondani). A chemical control of this pest is known and will be tried at Pasto.

The observations on the insect pollinators of alfalfa, red clover, and white clover made during the year confirmed previous observations. Commercial production of alfalfa seed is probably possible in the hot climate areas where carpenter bees, *Xylocopa* spp., and to a lesser extent the honeybee, *Apis mellifera* L., serve as pollinators. White clover seed could be produced in the cooler regions where both the honeybee and the bumblebees, *Bombus* spp., are active pollinators. Except for occasional pollination by bumblebees and anthophorids, probably of the genus *Thygater*, there is no seed-set by red clover in the country. Studies of red clover plantings in the "paramo," where herb-visiting bumblebees are more abundant, and of the nesting habits of the anthophorids will be made to find if the seed-set of red clover can be increased to commercially acceptable quantities.

It was definitely established during the year that the early infestations of corn by the budworm, *Laphygma frugiperda* (Smith), originated from eggs deposited on the germinating corn plants. This point emphasizes the need for very early applications of insecticides. Data from light traps and from staggered plantings of corn have shown that the budworm is more abundant during the wet season than in periods of dry weather. An effort to increase the numbers of the wasp *Polistes canadiensis erythrocephala* (Latreille), a major predator of the budworm, proved inconclusive because the wasps did not establish nests in the receptacles that were placed in the field. A further study of the nesting habits of these wasps is needed.

The failure of the insecticide heptachlor to adequately suppress dipterous leafminers of the genera *Agromyza* and *Liriomyza* on beans, broadbeans, and potatoes in the Savannah of Bogotá causes suspicion that these pests are becoming resistant to this compound. Biological studies and additional control studies were initiated in the hope of finding a means of control. The biological studies included life cycles and field observations. One important observation in the field studies was that the "toston" of the potato, *Liriomyza* sp., is attacked by many parasites that may help give practical control of this pest.

LIVESTOCK PESTS

The problem of cattle ticks made a control study necessary. The effectiveness of sprays of several insecticides was tested at Montería during the year. The tests showed that a spray of 0.5% toxaphene was especially effective against the complex of species of ticks on beef cattle in the Montería area. Co-ral, chlordane, a mixture of DDT with BHC, heptachlor, and Sevin were also acceptable, but were not as effective as toxaphene. A spray of malathion was not as good as the other materials, but inadequate control may have been caused by the low concentration applied. During the tests, it was noted that the ticks are more abundant in the dry season than in the wet. Further tests will be made of the more effective materials.

Mixing DDT with bedding material prior to placing it below caged laying hens, combined with periodic application of a spray of Diazinon over the bedding, continued to give good control of larvae of the house fly, *Musca domestica* L. Residual sprays of Diazinon, lindane, and malathion also continued to be effective against adult house flies when the insecticides could be safely applied. The proprietary bait Tugon has proved to be excellent in the control of low populations of adult house flies in buildings.

Biting flies of the genera *Culicoides* and *Simulium* and many species of mosquitoes have presented other control problems for the technicians of the division. Observations made during the year indicate that indalone repels only the culicine mosquitoes while both Rutgers 612 and Metadelphene give protection against the full range of pests. Metadelphene has an especially prolonged effectiveness.

STORED GRAIN INSECTS

In tests comparing sprays and dusts of malathion and PBP (a mixture of piperonyl butoxide with pyrethrins) it was found that the dusts were more effective in protecting stored beans and corn from insect pests. The effectiveness of dusts was more pronounced in beans than in corn and more marked with PBP than with malathion in both of the stored grains. Protective dusts of both malathion and PBP continued to give good control of the primary pests of stored beans and corn, but there is good evidence that neither of them adequately protects stored corn from the surface-feeding caterpillars *Corcyra cephalonica* (Staint), *Ephestia kuhniella* Zeller, and *Plodia interpunctella* (Hübner).

The addition of acrylonitrile, a fumigant highly effective against the small rice weevil *Sitophilus sasakii* (Takahashi), to mixtures of carbon tetrachloride with either carbon disulphide or ethylene dichloride failed to increase the effectiveness of these mixtures against the pests of stored corn. The acrylonitrile combined chemically with the carbon disulphide and the resultant mixture was generally less effective than the standard fumigant. The mixture of acrylonitrile with ethylene dichloride and carbon tetrachloride increased the toxicity of the mixture to the small rice weevil. This increase was offset, however, by the increase in the numbers of the Angoumois grain moth, *Sitotroga cerealella* (Olivier), when the mixture was used at slightly lower dosages. The increase in Angoumois grain moth was probably caused by the lowered competition of the small rice weevil.

In a test of fumigants at rather high temperatures, a very low dosage of Phostoxin (based on aluminum phosphide) was as effective as the mixture of ethylene dichloride:carbon tetrachloride against the insect pests of stored corn, but the Phostoxin left a very disagreeable odor in the grain for at least six weeks after it was applied. Neither calcium cyanide nor the mixture of carbon disulphide:carbon tetrachloride was effective in this test. The lowered effectiveness of the materials was probably the result of relatively high temperatures. This test is to be repeated under less severe conditions.

Upper surfaces of stored corn in the hot climate region are often rapidly reinfested by Angoumois grain moth after fumigation. Mixing protective dusts of either malathion or PBP in the upper 20 cm. of grain prior to fumigation proved to be effective against the moth. The fact that the surface layer of protective dust alone gave a high degree of protection to the grain is a further indication that the principal source of infestation of stored grain is from insects that are in the storeroom and not from those brought in from the field with the harvested grain, since otherwise the damage would be uniform throughout the grain.

The use of poisons of the anticoagulant type, such as Warfarin or Pivalyn, have proved effective against various races of rats, *Rattus rattus* L. Rats have increased alarmingly throughout Colombia during the past few years and are causing great damage to corn in the field. Poison baits in cooked rice or water were found to be effective against these pests. The addition of a small amount of salt to the rice bait seemed to conserve it longer and to make it more palatable. Bait stations were established in fields highly subject to rat damage. Both the rice and water baits were placed daily for ten days before planting and again for ten days after the tasseling of the plants. This held down rat damage to the germinating corn and to young ears, but was variable in its effects against the general rat population in the region since it was applied only in comparatively small areas. The intensive use of the anticoagulant baits continued to give control of rats in storerooms within four or five days.

CROP PESTS

BEANS

The leafhopper *Empoasca kraemeri* (Ross and Moore) is the most severe bean pest in Colombia. Dusts of DDT, or DDT mixed with toxaphene, and sprays of either endrin or parathion have given control, but neither of the dusts is optimum for this purpose and the two spray materials are considered too dangerous for general use. Other insecticides were therefore tested for their effectiveness against the leafhopper. Sprays of mixtures of DDT and toxaphene proved to be highly effective. Sprays of DDT (this compound is sometimes highly phytotoxic in beans), endrin, and teladrin (the "WL 1650" of former reports) were nearly as effective as the DDT-toxaphene mixture. Sprays of ethion, parathion, and Sevin did not have as long an effective residue as the first named insecticides, and dusts of DDT or the mixture of DDT and toxaphene were not as effective as the sprays. Several other insecticides also seemed promising, and will be compared with the best of the known materials in future tests.

In past work, the bean varieties Sánchez and Uribe Redondo were found to be attacked less by the leafhopper than were the other common varieties. Seed from individual plants selected for having minimum numbers of leafhoppers on them will be grown in plant-rows for further observation. The newly released varieties and promising advanced lines of beans will be observed in the same way to try to obtain other sources of resistance to this severe pest.

The attempt to control the leafminer of beans on the Savannah of Bogotá with sprays of aldrin, DDT, heptachlor, and parathion was unsatisfactory. As noted previously, the chemical control of this type of pest in this region has been generally ineffective. A test of newer insecticides is to be made and the collection of bean varieties will be examined for possible sources of resistance to the leafminer.

CORN

None of the newer insecticides tested against the budworm of corn proved as effective as the materials presently used. Of the new materials, heptachlor epoxide, Hercules 3653, methyl demeton, and Phosdrin were phytotoxic to the corn. Baits or sprays of DDT mixed with toxaphene and baits of aldrin were slightly better than baits or sprays of toxaphene alone. The optimum proportions, by weight, for the control of the budworm appear to be one part of DDT to five parts of toxaphene.

Baits of *Bacillus thuringiensis* Berliner, made by mixing the spores of the pathogen with a granular organic carrier, were highly effective against the budworm at Nataima but less satisfactory at Tulio Ospina and Palmira. Baits containing 5% spores were as effective as those of 10% when the total quantity of spores applied per hectare was the same. The effective dosage of spores for the control of the budworm is 2 kg./ha. Young corn was not protected from the budworm by the application of bands of insecticides around the plots, because the female places the eggs on the young corn plants and the larvae do not migrate across the fields.

In a preliminary test, two late applications of teladrin gave a highly promising control of the corn stalk borers, *Diatraea saccharalis* (Fabricius) and *Zeadiatraea lineolata* (Walker). However, it is doubtful if the use of insecticides against these pests is practical. The use of resistant varieties and hybrids is a more promising means of control. Work toward this end is in progress.

One of the outstanding insect collections of Latin America is located at Tibaitatá.

POTATOES

Control of the toston, the dipterous leafminer of the potato, has been very unsatisfactory in the last few seasons. In tests during the year, the experimental compound Hercules 3653 gave promising results but no other materials gave satisfactory control. Both teladrin and the mixture DDT-toxaphene actually caused an increased population of the toston, probably because they killed the parasites of the pest without an appreciable kill of the pest itself.

The lepidopterous leafminer, *Gnorimoschema* sp., was effectively controlled by teladrin and endrin but not by either Hercules 3653 or heptachlor.

Demeton, malathion, and Thiometan were the best of the materials tested against the complex of aphids that attack maturing potatoes. Parathion, previously noted as effective against these aphids, was unsatisfactory in this year's tests.

The mixture of DDT with heptachlor continued to be effective against the complex of potato pests at Obonuco during the year. The poor showing of the insecticides at Tibaitatá, however, necessitates further testing of new materials, especially for the control of the toston.

Studies of resistance of potatoes to their insect pests at Tibaitatá were hindered by drought and frost. Tests at Obonuco showed that varieties of *Solanum rybinii* were promising as sources of resistance to both the dipterous and lepidopterous leafminers. To lower the costs of this study, further resistant tests will be restricted to these leafminers, since they are the most severe and difficult to control with chemicals.

SMALL GRAIN CROPS

Tests of insecticides in small grain crops during the year confirmed the results of previous work. Early applications of demeton, endrin, teladrin, and toxaphene protected young rice from the common insect pests but did not reduce the quantity of the disease hoja blanca, which is transmitted by the fulgorids of the genus *Sogata*. The use of insecticides has given increased yields when hoja blanca-resistant varieties of rice were used in the experiments. High infestations of the barley leafhopper, *Cicadulina pastusae* (Ruppel and DeLong), the vector of the enanismo disease of barley in the Pasto region, were not controlled with early applications of DDT or demeton.

The leafminer of barley, *Agromyza* sp., was controlled with sprays of aldrin, DDT, endrin, and parathion. Varieties of barley that appear to be resistant to this pest have been selected in cooperation with the agronomists of the barley improvement program.

Birds continue to be major pests of ripening small grains in all parts of the country. Control measures for birds are very uncertain, but the repellent Ornirep has shown promise in wheat and will be tested further.

Experimental wheats in the hot climate region at Palmira are attacked by borers of the genera *Diatraea* and *Ruppellia*. The best materials from experiments on the control of similar pests in corn are to be tested in wheat in an effort to protect these important plantings.

VEGETABLE CROPS

None of the materials tested against the broadbean leafminer, *Agromyza* sp., were satisfactory on the Savannah of Bogotá. This may be part of the general problem of unsatisfactory control of dipterous leafminers noted above. The varieties of broadbeans available at present are extremely variable in their growth, and proper timing of insecticide applications is difficult. Further studies of broadbean pests will be delayed until a satisfactory variety is available.

Teladrin proved to be highly effective against the tomato pinworm, *Keiferia lycopersicella* (Busck.), in tests at Palmira. Lead arsenate, parathion, and toxaphene were also effective, while malathion and Phosdrin gave moderately acceptable control.Methoxychlor, PBP, and Sevin did not provide satisfactory control of the tomato pinworm at the dosages used.

SPECIAL STUDIES

Corn stunt, a virus disease, has been previously recorded in Colombia but plants suspected of having this disease have been scarce. During the latter part of the year, however, plants with symptoms of corn stunt became common at Tulio Ospina. A known vector of this disease, *Dalbulus maidis* (DeLong and Wolcutt), is also common in corn in this region. In a preliminary test at the station, adults of *D. maidis* were shown to transmit the disease from infected to healthy seedling plants. This gives a basis for suspecting that one of the virus diseases of corn in Colombia is actually corn stunt.

The barley leafhopper, *Cicadulina pastusae*, was shown to cause vein-swelling (a systemic toxemia produced by this and several related leafhoppers) on the grass *Bromus catharticus* Vahl., but vein-swelling did not occur on other grasses exposed to the feeding of this leafhopper at Obonuco. Corn in fields at this station also showed such vein-swelling, probably caused by the feeding of the barley leafhopper. At Palmira, a region where *Cicadulina* is not found, wheat also displays such swelling. It is suspected that *D. maidis*, a species related to *Cicadulina*, may be the cause of the swellings and a test of *D. maidis* in wheat will be made at this station.

The weed-killer simazin gave excellent control of weeds in corn in moist soils at Nataima and Tibaitatá, but no control in dry soils at the latter station. At Palmira it failed to control the common annual weed grass pajamona, *Leptechloa filiformis* (Lam.) Beauv. Dinitrobutylphenol was effective as a pre-emergence weed-killer in wheat, barley, and beans at Tibaitatá. 2,4-D was less effective in the small grain crops than the dinitro, and amiben failed completely to control the weeds in beans at both Tibaitatá and Palmira. In a large-scale trial, CMU failed to adequately suppress nutgrass, *Cyperus* spp., at Tulio Ospina. CMU had shown promise against these severe weed pests in small plot trials. Periodic application of dalapon and TCA was satisfactory in controlling weeds along fence rows and roadsides, and the mixture of 2,4-D with dalapon appears promising for clearing roadsides of shrubs and heavy weed growth.

The use of dairy breed steers for beef production, such as these Normando steers at Tibaitatá, is becoming very common in all parts of the world.

Beef Cattle

During the past year experimental work in the beef cattle program was continued on the four projects of management, nutrition, breeding, and physiology. These are being conducted at five experiment stations: Tibaitatá, Palmira, Turipaná, Armero, and La Libertad.

Two men were added to the program during 1961, making a total of eleven. Two have returned from the United States with M.S. degrees, one in nutrition and the other in physiology. A third man is presently studying for the master's degree in animal breeding. Three of the remaining men are to leave for the United States during 1962 to begin their studies; two will study nutrition and one is to study breeding. This will leave seven men actively engaged in the program.

Within Colombia there is still much optimistic discussion as to the importance of the beef cattle industry to the national economy. It is stated that beef will replace coffee as the principal export commodity. This could become possible with an improvement in beef quality. This improvement can be attained by an improvement in the quality of the breeding animals, and also by an improvement in management and feeding practices. The latter can be obtained much more rapidly than the former.

MANAGEMENT

The pasture and herd management practices initiated several years ago were continued at all stations. These practices are the ones necessary for a sound and efficient beef cattle production program in the different regions of the country.

NUTRITION

TIBAITATA

An experiment was started on the nutritive value of oat silage, with and without concentrate, and to determine the efficiency of several growth stimulants such as tranquilizers, antibiotics, and hormones for the fattening of steers in confinement.

Ninety crossbred Normando steers were assigned to ten experimental lots of nine steers each, according to body weights. Five diets in two replications of nine steers each are being studied. These diets are (1) oat silage alone (control); (2) oat silage plus 2 kg. of grain supplement per animal daily; (3) oat silage plus supplement plus 2.5 mg. of tranquilizer per head daily; (4) oat silage plus supplement plus 80.0 mg. of terramycin per head daily; and (5) oat silage plus supplement plus tranquilizer plus terramycin. In addition, three steers of each lot were implanted with 36 mg. of stilbestrol; three of each lot with 200 mg. of progesterone and 20 mg. of estradiol benzoate; and three were left as non-implanted controls.

At the end of 112 experimental days the cumulative average daily gains per steer were 0.74, 1.25, 1.28, 1.30, and 1.33 kg., respectively, for the steers on the five diets.

Average daily silage consumption by the steers on each of the diets was practically identical. The silage was fed free-choice three times per day to all groups. The efficiency of conversion of the silage to meat was greatly influenced by the concentrate fed, and to some extent by the other growth stimulants. It required 32.31, 18.63, 18.25, 17.90, and 17.81 kg. of silage to produce 1 kg. of weight gain, respectively, by steers on each of the five diets.

The cumulative average daily gains for all steers without hormones, all steers with stilbestrol implants, and all steers with progesterone plus estradiol implants were 1.06, 1.29, and 1.19 kg., respectively, during the first 112 days of the experiment.

A cooperative grazing experiment with the pasture and forage crops program was initiated simultaneously with the confinement fattening study. This experiment is a study of beef production and economic yield per hectare-year of four grasses and two legumes seeded in eight different mixtures. Each of the eight mixtures is being studied in two replications in 1-hectare plots. The put-and-take animal management system is being used. Thirty-two crossbred Normando steers were assigned, according to body weights, to the 16 experimental pastures as tester animals, two to each experimental plot. One tester steer from each pasture was implanted with 24 mg. of stilbestrol. In addition, non-hormone-treated steers are introduced and removed from each pasture according to the amount of forage available.

The cumulative average daily gain during the first 112 experimental days ranged from 0.96 kg. for the steers on the orchardgrass-red clover mixture to 1.18 kg. for the steers on the ryegrass-white clover mixture.

Carrying capacity ranged from 4.11 steers per hectare on the fescue-white clover mixture to 2.09 animals per hectare on the ryegrass-orchardgrass-fescue-red and white clover mixture.

Beef production per hectare ranged from 480 kg. on the fescue-white clover mixture to 256 kg. on the orchardgrass-red clover mixture. Steers on naturally occurring kikuyu grass produced 445 kg./ha. of beef during this period.

The cumulative average daily gain for all steers without hormone implants was 0.95 kg., and 1.13 kg. for all stilbestrol-implanted steers.

PALMIRA

A steer fattening experiment in confinement was completed during this year. Thirty-two crossbred Cebú steers were assigned to eight experimental lots of four steers each. The experiment continued 224 days. Four diets in two replications were studied. In addition, half the steers were implanted with 200 mg. of progesterone and 20 mg. of estradiol benzoate. The four diets consisted of (1) corn silage alone; (2) corn silage plus supplement; (3) sorghum silage plus supplement; and (4) green chopped sorghum plus supplement.

The cumulative average daily gains produced by the steers on the four diets were 0.43, 0.77, 0.44, and 0.60 kg., respectively. Hormone implants had little effect upon growth rate.

Calculated yield of beef production per hectare based on forage production, consumption per kilogram of gain, and average daily gain indicates that it is possible to produce 4,125 kg. of beef per hectare from corn silage, and 3,369 and 4,062 kg. of beef per hectare-year, respectively, from sorghum silage and green chopped sorghum.

A grazing experiment of 392 days' duration, divided into two periods of 196 days each, was finished during this year. The object of this experiment was to study the nutritive value of pará, puntero, pangola, and guinea grasses. These grasses were seeded in plots of 2 hectares each, in two replications. Thirty-two crossbred Cebú steers were assigned to the eight experimental pastures as the tester animals, four to each pasture. In addition, put-and-take steers were introduced and removed in each pasture according to the amount of forage available. The first period was conducted without irrigation and without fertilization of the pastures. In the second period, urea was applied uniformly to all pastures. Half the tester steers were implanted with progesterone and estradiol.

During the 392 days, the steers on puntero had the highest average daily gain, 0.70 kg., and those on guinea the lowest, 0.55 kg. Gains on pará and pangola were intermediate, with averages of 0.64 and 0.59 kg. daily. Both pará and puntero produced 656 kg. of beef per hectare, while pangola and guinea produced 569 and 511 kg., respectively. The amount of total digestible nutrients (TDN) calculated as necessary to produce 1 kg. of weight gain ranged from 7.62 kg. in puntero to 8.97 in guinea. Economic yield per hectare varied between 821.41 and 1,151.38 pesos without the cost of the urea, and between 211.41 and 551.38 pesos including it. The hormone-implanted steers gained, on an average, 52 kg. more per steer than the non-hormone-treated steers.

TURIPANA

A steer fattening experiment on pasture was finished during the past year which had the major objective of comparing the growth rates of Cebú, Romosinuano, and Costeño con Cuernos steers on pasture during a 168-day period. Forty steers of each breed were used, and half of each breed were implanted with 200 mg. of progesterone and 20 mg. of estradiol benzoate.

These Normando dairy breed steers have made exceptionally good gains in a dry-lot fattening experiment at Tibaitatá.

The cumulative average daily gains of the non-implanted steers were 0.64, 0.49, and 0.41 kg., respectively, for the Cebú, Costeño con Cuernos, and Romosinuano steers. The average daily gains for the hormone-treated steers of each breed were found to be 0.84, 0.68, and 0.58 kg., respectively. The growth rate of the non-hormone-treated Cebú steers was found to be significantly higher (1%) than that of the steers of the other two breeds, and the hormone-treated steers of each breed yielded a highly significant growth rate over the non-hormone-treated steers of each breed.

During the latter part of the year another pasture fattening experiment was initiated. In this experiment 60 Romosinuano steers are being used. Three groups of 20 steers each have been selected. One group is a control, one was implanted with 24 mg. of stilbestrol, and the third group was implanted with 200 mg. of progesterone and 20 mg. of estradiol benzoate. The experiment was started in December, 1961, and results will be reported later.

ARMERO

In late 1961 a steer fattening experiment was initiated at this station. Thirty-six Cebú steers were separated into three groups of 12 steers each. One group was utilized as a control, one group was implanted with 24 mg. of stilbestrol, and the third with 200 mg. of progesterone and 20 mg. of estradiol benzoate. The results of this experiment will be presented in a later report.

LA LIBERTAD

A steer fattening experiment on pasture was finished during the past year, comparing the growth rates of steers of the San Martinero and Casanare breeds. Half the steers of each breed were treated with the same dosage of progesterone and estradiol benzoate reported in experiments at other stations.

During the 168-day experiment, the average daily gains of hormone-treated and non-hormone-treated San Martinero steers were 0.49 and 0.55 kg., respectively, while the Casanare steers had average daily gains of 0.38 and 0.48 kg. These differences in growth rate were highly significant within and between breeds.

Near the end of the year another pasture fattening experiment was initiated. In this, as in those at Armero and Cereté, the effect of hormone implants upon growth rate of steers on pasture will be studied. The effects of stilbestrol and of a combination of progesterone and estradiol benzoate upon growth rate are being investigated. Thus three similar experiments are being conducted at three stations, but with a different breed of steers at each location.

BREEDING

TIBAITATA

Since 1957, breeding and selection experiments have been conducted with the Angus herd at this station.

In the basic breeding and selection experiment, groups of cows have been formed that are mated to a determined sire either by natural service or by artificial insemination. Records are maintained for each of the breeding groups. These data are used principally for a bull proving study, and for record of performance data of the offspring. Body weights are recorded for the calves at determined periods until they reach 24 months of age.

The record of performance of each animal is based on its growth rate from birth to weaning, and from weaning until 18 months of age. The first period reflects the influence of the dams as to milk production, and the second the genetic potential of the animal itself. Since 1957, performance data have been maintained on 49 calves (30 males and 19 females). The average birth weight for these animals was 23.1 kg., average weaning weight was 217.0 kg., and average weight at 18 months was 354.4 kg. The cumulative average daily gain from birth to weaning was 0.742 kg., and from weaning to 18 months, 0.482 kg.

During the past year similar breeding and selection experiments were started with a small herd of Red Polled females. These females were divided into two groups. One group is being mated to a Red Polled bull and one to an Angus bull. Growth data of the crossbred Red Polled × Angus calves will be compared with the growth rates of the purebred Red Polled and Angus calves.

TURIPANA

Breeding and selection of the Romosinuano herd at this station has been in progress since 1936. However, the project was modified in 1959, and since that time four experiments of breeding and selection have been conducted. These experiments are similar at all stations and for all the breeds of cattle being studied. Thus, the results are based on the same factors presented for the Tibaitatá Angus herd.

Calving percentage has been 90.7% in over 400 head of cows bred each year. Mortality in calves from birth until weaning was 12.5%. The highest mortality occurs between birth and three months of age (10.0%). Weaning percentage based on the number of cows entered in breeding groups was 78.2%, and based on number of calves born, 87.5%.

Record of performance data have been completed on 418 offspring. Average birth weight of all calves of both sexes was 30.0 kg., weaning weight 194.0 kg., and at 18 months of age 285.8 kg. Cumulative average daily gain from birth until weaning was 0.60 kg., and 0.30 kg. from weaning until 18 months.

The bull proving study is based on the record of performance of the offspring from 30 cows mated with one bull during an 11-month breeding period. The performance data of the offspring are taken at 9 months (weaning) and 18 months of age. At the present time 20 bulls have been proven. Cumulative average daily gain from birth until weaning ranged from 0.66 to 0.44 kg. in the offspring of the 20 different bulls, and from 0.44 to 0.19 kg. in the period from weaning until 18 months in the same progeny.

In an attempt to control inbreeding in the herd, two major lines and two minor lines of females have been formed. The formation of these lines was based upon the sires and not the dams. An attempt will be made to maintain these lines, and perhaps even sub-lines within each line, so that a line-crossing program can be followed in future matings.

In an experiment to study the effect of age of dam at first calf upon future production, body size, and growth rate of the progeny, three breeding groups of heifers were formed. One group (control) was formed with females 24 months of age with a male 24 months of age. A second group was formed with both the male and the females 18 months of age, and a third with a male of 24 months of age and females 18 months of age. Data on calving percentage, mortality, weaning weight, and weight at 18 months of age of progeny were recorded. In addition, body weights of the dams were recorded at each calving. During 1962, the last group of calves (two calving seasons) will become 18 months old. However, it appears that breeding before 24 months of age under existing conditions is not practical.

ARMERO

At this station the same breeding and selection experiments reported at other stations are being conducted with Cebú and Romosinuano herds.

Calving percentage in the Romosinuano herd was 95.3%. Average birth weight of the calves was 26.6 kg., average weaning weight 185 kg., and an average body weight of 260 kg. was reached at 18 months of age.

The calving percentage in the Cebú herd was 92.8%. Average birth weight was 27.8 kg., average weaning weight 227.5 kg., and average weight at 18 months of age 366.5 kg. Data for bull proving studies have been completed on only one bull. His progeny had a cumulative average daily gain of 0.77 kg. from birth until weaning, and of 0.50 kg. from weaning until 18 months of age.

LA LIBERTAD

The same breeding and selection experiments conducted at other stations with other breeds are being carried out with the San Martinero breed at this station.

Average birth weight of the San Martinero calves was 29.9 kg., average weight at weaning 218.4 kg., and 291.9 kg. at 18 months of age. Data have been collected on six bulls in the proving program. Cumulative average daily gain from birth until weaning ranged from 0.61 to 0.76 kg., and from 0.30 to 0.33 kg. between weaning and 18 months of age.

Similar experiments are being conducted with a purebred Romosinuano herd, and with a group of Romosinuano females that are being mated to an Angus bull. While data are still incomplete, it appears that the Angus bulls are adapting well in this area, and that their crossbred progeny will gain more than purebred criollo animals under similar conditions.

PHYSIOLOGY

During the past several years experimental work has been conducted on growth physiology and on environmental and adaptation physiology in cattle of the Angus and Holstein breeds at Tibaitatá.

An attempt has been made to measure thyroid activity in animals of these two breeds by the determination of blood cholesterol and protein-bound iodine. The protein-bound iodine levels have been consistently higher in the Holstein breed (5.28 gammas %) than in the Angus breed (3.60 gammas %). These are average figures for animals of both sexes in both breeds. However, blood cholesterol levels were also found to be higher in the Holstein breed (156.47 mg. %) than in the Angus breed (113.00 mg %). Normally one expects to find an inverse relationship between cholesterol and protein-bound iodine. High levels of protein-bound iodine and low levels of cholesterol usually indicate a high level of thyroid activity.

In a continuation of the environmental studies on hematology and blood components, blood volume determinations were made in Angus and Holstein cattle. Total blood volume increases with age in the cattle of both breeds, and blood volume expressed as a percentage of body weight decreases with age. Holstein cattle had a higher total volume (28.89 liters) than Angus cattle (24.67 liters). Blood volume expressed as a percentage of body weight was also higher in Holstein cattle (13.37%) than in Angus cattle (11.80%).

Dairy Science

Dairying in Colombia is conducted under a wide range of climatic conditions which influence the practices used in the different regions. In the higher and cooler areas good levels of production can be realized through adequate management and nutrition. However, since these areas are restricted in size and are heavily populated, economic and social pressures tend to increase the proportion of cultivated land and decrease that devoted to dairying. The dairy industry will be continued in these areas and production can be increased, but the potential will be limited.

If Colombia is to increase milk production, the hot climate regions must play a major part; they have land available and contain a number of large population centers. The warm climates cover much of the country and though they are unfavorable for dairying and pose difficult technical problems, these regions offer real possibilities for an increase in total milk production. In spite of their good potential, under present technological conditions milk production in them will probably not increase rapidly enough. A breakthrough in hot climate dairy research is definitely needed. No recent data are available, but in Colombia the low consumption of milk (about 50 liters per capita in 1956) and of meat (less than 30 kg. per capita per year) indicates that shortages of these foods exist and that the average Colombian diet is low in animal proteins.

A dairy industry already exists in the hot climate areas but production, both total and per cow, is low. Some dairymen are trying to improve production by introducing European breeds, improving pastures, and using silage. Unfortunately, few data are available to guide them in their improvement efforts.

Work during 1961 was conducted at the same farms as during 1960: Tibaitatá, Palmira, Obonuco, El Nus, Turipaná, and Toluviejo. The main nucleus of Costeño con Cuernos (CCC) cattle has been moved to Turipaná.

HOLSTEIN HERDS

Holstein research herds are located at Tibaitatá, Palmira, and Obonuco. In planning the research organization and facilities it was believed that European breeds would be well adapted to these three regions, and in fact there are several herds of Holstein cattle already in them. No other breed has shown greater milk production potential in environments where they are well adapted. Also it was decided to use only one breed, since intensification practices applicable to one of the European dairy breeds can usually be applied to another, and the use of a single breed simplifies research trials. These herds allow the workers in the research program to gain management experience. The problems encountered in managing the experimental herds generally reflect the problems of the region, and the production results serve to predict what might normally be expected on a commercial farm under similar conditions.

PRODUCTION

The average size of experimental herds has been increasing and a greater number of first-calf heifers freshened during the year, except at Palmira. The average production per 305-day lactations terminated during the year was 5,226, 4,293, and 3,773 kg. of milk at Tibaitatá, Palmira, and Obonuco, respectively. Average percentage of butterfat for these 305-day lactations was 3.55, 3.59, and 3.81, respectively. The average daily production per cow day in milk was 15.8, 13.6, and 11.6 kg. for the three herds. The herd at Tibaitatá continues to be the highest producing, but the steady progress of the herd at Obonuco is a better index of the improvement a dairyman might expect through better management, better feeding, and the use of better bulls. At Obonuco the production per cow day (the average for all cows in the herd whether in milk or not) was 7.9 kg. in 1959, 8.99 in 1960, and 9.3 in 1961. Prior to 1959 complete records are not available but production was much lower. This is an increase of 511 kg. per cow during the last two years.

Thus far, experimental trials have not adversely affected milk production of the herds but in the future, as the research program increases in scope, a larger percentage of the animals will be used in various studies and production will undoubtedly be affected.

BREEDING EFFICIENCY

Breeding efficiency in the three Holstein herds is low, about the same as reported for the previous year. Again, Palmira had the lowest efficiency. Up to the present there is no known reason for this low efficiency, since no infection has been found in the herds. Herds have been shown to be free from contagious abortion and tuberculosis. Other undetermined diseases such as leptospirosis and vibrio fetus could be present. Low breeding efficiency also seems to be common among commercial herds and is a problem of first importance which must be given attention.

NATIVE BREEDS

The bovine is not indigenous to this hemisphere but there are several breeds considered as native and locally referred to as "criollo" breeds. The similarity of these breeds to the parent stock, most of which probably originated in the Iberian Peninsula, is not known but they have well-defined characteristics and are relatively uniform within a breed.

The dairy program is working with two of these breeds, namely the Blanco Orejinegro (BON) and the Costeño con Cuernos (CCC). The BON herd is located at El Nus in Antioquia. It is not known whether this breed exists outside of Colombia. The CCC herd has been located for several years at Toluviejo but the main nucleus is now at Turipaná, a new farm at Cereté near Montería on the northern coast. This breed also exists in Central America and in northwestern Venezuela and is usually referred to as Criollo Lechero outside of Colombia.

In addition to the pure BON at El Nus there is a group of 3/4 BON—1/4 Jersey (3/4 BON—1/4 J) which were developed by using Jersey bulls on BON cows and then mating the half-blood offspring with BON bulls. As will be noted later in this report these animals, even though their production is discouragingly low, do produce considerably more milk than the BON. This group at present is being maintained by using quarter-Jersey bulls. These animals are uniform in size

TABLE 1.

Summary of production of BON and 3/4 BON—1/4 J crosses that terminated milk records during 1960 and 1961.

	1960		1961	
	BON	¾ BON—¼ J	BON	¾ BON—¼ J
No. of lactations	128	42	145	55
Av. milk per lactation (lb.)	533	1,587	650	1,584
Av. days in lactation	71	151	82	165
Lactations of less than 50 days' duration:				
No.	64	10	71	15
% of total	50	24	49	27
First-calf heifers completing lactations:				
No.	16	4	39	12
% of total lactations	13	10	27	22
First lactations of less than 50 days' duration:				
No.	14	3	20	3
% of heifer lactations	88	75	51	25

and conformation and in general have the same color as the pure BON; in fact, they usually cannot be identified visually as having Jersey blood. They seem to be as well adapted to the rigorous environment as the BON.

PRODUCTION OF THE BLANCO OREJINEGRO

Although production of the BON and the 3/4 BON—1/4 J, as shown in Table 1, is very low, the increased production of the BON-Jersey crosses is considerable and would seem to indicate the possibility of improving the cattle of the region through crossing with European stock. It was decided, however, to evaluate the present animals before embarking on further crossing studies.

It is interesting to note that in 1960 the percentage of first calf heifers that had lactations of less than 50 days' duration was considerably greater than the average for the herd. In 1961 the percentage of short lactations for heifers and for the entire herd was about the same. Whether or not this is a reflection of better management is not known but such could be the case because it is a characteristic of these animals to retain their milk when not stimulated first by the calf. In these studies the cows have been milked without the calf at their side, and perhaps better training of heifers before calving has resulted in better milk let-down.

If calculations are based on cow days, the pure BON were in production 26% of the total days of the year while the Jersey crosses were in production 46% of the total days. Also the Jersey crosses average 9.1 lbs. of milk per productive cow day while the BON average only 7.1 lbs.

PRODUCTION OF COSTENO CON CUERNOS

The CCC have not been studied under the system of milking without calf for as long a period as have the BON, 1960 being the first complete year of milk recording under this system. The two years' data are summarized in Table 2.

These data indicate that the CCC has a greater potential for milk production than the BON. Though the two breeds have not been studied under the same conditions, the average production for the CCC during 1961 was 390 kg. (858 lbs.) of milk in an average of 119 days, while the production for the pure BON was only 650 lbs. of milk. Also the average age of the CCC was less than that of the BON and the data in Table 2 indicate that the CCC will increase in production. The production of the CCC was lower than that of the BON-Jersey crosses.

Like the BON, the CCC have a marked tendency to hold up their milk unless stimulated by the calf. Production up to 2,000 kg. is not uncommon when these cows are milked with calf. Milking without calf has lowered production. Thus it may be a problem of milk let-down rather than milk-producing potential that keeps this breed from entering commercial production on a larger scale.

FORAGES

If the Colombian dairy industry is to improve its efficiency under present economic conditions, it must do so largely through better use of forages, since most common feed grains are expensive in relation to the price of milk. Some by-product feeds are lower in price than the feed grains but their distribution is limited. Within the dairy research program, forage studies are being increased in scope.

GRASS-LEGUME MIXTURES

In cooperation with the pasture and forage program, a pasture grazing trial was initiated in October, 1960, at Tibaitatá for the purpose of comparing a mixture of kikuyugrass and white clover with a mixture of orchardgrass, perennial ryegrass, white clover, and red clover. This study is being conducted with six plots (three replications) of 0.8 hectare each. The put-and-take method has been followed, and the adding or removal of animals has been based upon visual observation of the status of the pasture, plus clipping data taken by the forage crops personnel to estimate forage. The following data were collected between October 4, 1960, and October 9, 1961. During this period pasture growth was affected by dry weather and water, for irrigation was not available. The calculated TDN production of the kikuyu and clover was 7,106 kg./ha. as compared with 4,292 for the other mixture. The carrying capacity of the kikuyu mixture was 2.6 cows per day per hectare and for the orchardgrass-ryegrass mixture, 1.4. Milk production per cow was higher for the latter mixture by about 1 kg. per cow per day and this difference would probably have been greater if moisture conditions had been more favorable for pasture production.

CORN SILAGE VS. SORGHUM SILAGE

Two feeding trials have been carried out at Palmira comparing corn silage and sorghum silage for milking dairy cows. In both trials three periods of 21 days each were used in a double reversal design. The average production in the first trial was 10.7 kg. per cow per day of 4% corrected milk for the corn silage fed group and 9.9 kg. for the group which received sorghum silage. The results for the second trial were 16.2 and 15.0 kg., respectively. These results show an advantage of approximately 1 kg. of milk per day per cow

TABLE 2.

Summary of milk production of CCC when milked without calf, 1960—1961.

No. lactations	1960			1961		
	No. cows	Av. days lact.	Kg. milk	No. cows	Av. days lact.	Kg. milk
1	65	64	122	75	123	371
2	30	92	258	69	106	372
3				22	143	509
Average	—	73	165	—	119	390

Making oat silage in a stack.

in favor of the corn silage. In the Cauca Valley, however, sorghum can be harvested several times without reseeding while corn must be reseeded after each cutting.

TYPES OF SILOS

No controlled studies have been made of the different kinds of silos. Since silage is not well known in Colombia, it was decided to gain experience with different types of silos. As would be expected, the vertical tower silos, the trench, and the bunker have all given good results. In addition to the silos, forage has also been stored in stacks with good results. While wastage and spoilage may be higher with the stack silo, the percentage loss probably would be inversely related to size. Relatively small stacks have been used for these observations. The forage is first stacked and well packed, covered with straw, and then with soil, or in some cases, only with soil. In general these stacks have shown considerable promise as a method by which a farmer can gain some experience with silage without investing in expensive facilities. The fact that the stack can be made at almost any site on the farm adds flexibility to the forage storage program.

MAINTENANCE OF BODY WEIGHT

Heifers and adult animals that do not conceive promptly often become overly fat, even when pasture is the only feed. It was therefore decided to study the amounts of oat silage required to effect a gain or loss of body weight. Three groups of five animals each were formed, using both heifers and dry cows, and were observed during 15 weeks. All groups received 30 kg. of silage per animal during the first week. Groups II and III received 20 kg. during the second week while Group I continued to consume 30 kg. during the remainder of the study. The second group continued to receive 20 kg. while the amount given to the third group was reduced to 10 kg. starting with the third week. During the 15-week period Group I gained an average of 16 kg., Group II lost an average of 14 kg., and Group III lost an average of 74 kg. It appears that between 20 and 30 kg. is sufficient to maintain body weight. If it is desired that excessively fat animals lose weight, it may be advisable to reduce the feeding of oat silage to as low as 10 kg. per day.

RAISING DAIRY CALVES

The introduction of limited-milk feeding systems for raising calves offers much promise in Colombia. The systems are economical, can free large amounts of milk for human use, and because they require more supervision, contribute to better control of many calfhood diseases. For these reasons the program has given considerable attention to calf nutrition and management.

LIMITED MILK FEEDING

About 200 calves have now been raised by the reduced milk system, using dry starter concentrate rations. It has been well demonstrated that these methods can be used successfully, with about a 50% reduction in feed costs during the first four months. Several trials were continued during 1961. At Obonuco the dry starter was used with 212 kg. of milk fed over a period of 56 days and compared with more liberal amounts of milk (457 kg.) fed over a longer period (112 days). Results show that the growth rate on 212 kg. of milk equaled the published United States standards. The herd at Obonuco consists mostly of grade Holsteins but during the year calves sired by Holland as well as United States bulls were used in the trials. Rates of gain were consistently higher for the calves sired by U.S. bulls.

At Palmira the most recent calf raising trial was to study the effects of feeding smaller amounts of milk (162 kg.) over a slightly shorter period (49 days). The control group received the treatment previously studied, 212 kg. of milk over a period of 56 days. Male calves fed the larger amounts of milk gained an average of 8.5 kg. more than the group given the smaller amount, over the 120 days of the experimental period. Females fed the larger amounts gained 3.9 kg. more than the other group. Over the milk-feeding period the over-all daily weight gain averaged about 570 kg., which is considered satisfactory.

Previously it was shown that the calves of the Costeño con Cuernos breed can be raised by bucket feeding. During the current year another study was carried out to determine the minimum amount of milk which can be fed with satisfactory results. Definite conclusions cannot yet be drawn from the study, but it appears that calves of this breed can be weaned as early as 77 days of age when they have received a maximum of 3.5 kg. of milk per day. In this case the calves received an average of 214 kg. of milk. Weaning earlier or reducing the amounts of milk gave more variable results. With better facilities and perhaps some managerial changes, less milk can probably be fed with good results.

HAY, GREEN FORAGE, AND GRAIN FEEDING

One group of Holstein calves was fed dry hay composed of red and white clover, ryegrass, and orchardgrass. It was planned to feed a second group the same forage mixture in the fresh state, but because of inadequate rainfall it was not possible to harvest suffi-

Feeding trial with dairy cows at Tibaitatá.

cient amounts of this forage mixture, so fresh kikuyu was substituted. Thus the two groups did not receive the same kind of forage. Each group was subdivided into two groups, the subgroups receiving either a maximum of 2.5 kg. or 1.8 kg. of grain daily over a 112-day trial period. The 24 males and 12 heifers in the fresh forage group and 23 males and 12 heifers in the hay group showed very little difference in daily gain, which averaged 534 g. and 542 g., respectively.

The over-all average daily gain of body weight for the animals which received a maximum of 2.5 kg. of grain daily was 564 g. and for the animals which received the lower amounts of grain, 509 g. Even the lower gain is equal to 1.12 lbs. daily, which is considered satisfactory. The dry forage tended to have an advantage over the fresh forage when the lower amounts of grain were fed (515 g. vs. 498 g.). Perhaps lowering the amounts of grain would result in a greater advantage for the dry forage.

ANTIBIOTICS

The amounts of aureomycin (Aurofac 2 A) recommended by the manufacturer are being fed in the milk to one group of Holstein calves up to 56 days of age and afterwards in the concentrate feed up to 112 days. A few calves have completed the 112-day experimental period and results to date show a slight advantage in body weight gain for the calves fed the antibiotic over a control group. The latter group consumed slightly more grain concentrate.

BLOAT

Bloat continues to be a problem on the improved pastures at Obonuco. Two trials have been completed in which 200 mg. of procaine penicillin was administered daily to one group while similar groups served as controls. In the first trial, with ten animals in each group, no cases of bloat appeared among the treated animals, in comparison with eight cases in four animals of the control group. In this trial there was only one case of bloat after the 30th day of the trial.

The second trial was conducted with 39 animals in the treated group and 41 in the control group. There were 19 cases of bloat in 14 animals between the 20th and 51st days in the non-treated group, and three cases in the treated group. One of the animals affected in the treated group was a heifer that had recently calved; this animal bloated twice and was also affected with brisket disease.

These results indicate that the penicillin was effective in both trials for longer periods than generally observed in the United States.

MINERAL SUPPLEMENTS

Very little information about mineral requirements of cattle in Colombia is available. In the experimental herds, supplemental minerals are usually given to the animals in an attempt to eliminate any deficiencies. Facilities have not been developed, nor have personnel been trained, to conduct precise mineral studies. However, a simple trial was conducted on the north coast at Turipaná with Costeño con Cuerno heifers. A total of 90 heifers, of about two years of age, were divided into three uniform groups. One group received a mineral mixture of salt, bonemeal, cobalt, and copper. A second group received only salt, while the third group received no supplements. Each group grazed in a field of pará pasture. Treatments were not replicated. The group receiving the mineral mixture consumed a daily average of 28 g. of supplement but consumption decreased steadily over a 280-day period. The group which received salt consumed an average of 14 g. daily with intake increasing slowly over the same period.

Weight gains over the 280-day period were 112, 94, and 103 kg., respectively, for the groups which received the mixture, salt only, and no supplements.

COFFEE MEAL

Several Latin American countries have large excesses of coffee. Very few alternate uses have been developed for coffee despite the fact that the surpluses pose a large problem.

By agreement, the surplus coffee cannot be used for beverage except in the country of origin. A possible use is to extract the fat from the bean for human consumption and to feed the residue to cattle. The results of a palatability trial and a growth trial were previously reported.

During 1961 another trial was conducted using Holstein males between 8 and 12 months of age. The coffee meal again did not give favorable results when compared with a basic ration. A blackstrap molasses mixture containing 33% coffee meal gave better results than coffee meal alone.

Range for cockerels, Tulio Ospina.

Poultry

The poultry industry in Colombia continues to be marked by rapid development, shown by the number of new commercial flocks established in the past year and increased interest in poultry raising. Colombian poultry producers continue to show more interest in egg production than in broilers.

The growing interest is in part a response to market demand, which greatly outweighs supply, and to continuing high prices and excellent profits. In addition, some of the world's best lines of poultry for meat or eggs, including hybrid crosses, are now produced in Colombia.

While the development of specialized poultry farms near large markets is increasing, the integration of small, well-managed farm flocks into the farming program of individual and family units in outlying regions proceeds at a very slow rate. By its nature, poultry raising should serve as a ready means of supplementing small farm income, of balancing income from other farm sources, and of supplying food of high nutritional value in the form of meat and eggs. However, lack of information among the farming population concerning the proper systems of disease control, feeding practices, and flock management results in poor efficiency and high losses. In addition, investigations are needed to show how poultry raising may be easily and economically integrated with other farming practices. Research on means for reducing feed costs and losses from disease, and on the development of simplified but effective methods of poultry management are considered to be of prime importance in Colombia. Development of the poultry industry in all regions of Colombia can greatly assist the small as well as the large farmer in becoming less dependent on a single income source and in improving the nutritional level in the general population.

Development of Facilities

During 1961 considerable emphasis was placed on the further development of physical facilities and on the purchase of equipment needed for research projects. Animal space and equipment within the poultry sections are considered adequate for the present scope of the programs.

TIBAITATA

Construction and installations of equipment in the fourth of seven existing buildings were completed, giving added facilities of 14 pens for pedigree hens and 6 other pens with a capacity of 100 hens each. Internal construction was started on a fifth building to create pen space for 1,400 hens.

PALMIRA

The general organization of this section was completed during 1961. Six range units were built for studies with 600 pullets. Further construction within the section was necessary to create temporary storage and feed mixing space so that a broad series of nutritional investigations could be initiated. Several large items of equipment were installed for use in research studies on nutrition, marketing, and technology.

TULIO OSPINA

The capacity of this section was increased slightly to create more floor pen space for studies with laying hens and broilers. The construction of ranges for pullets was completed and additional ranges were built for breeding cockerels. A small feed mixing room was also built and the equipment necessary for diet preparation installed. Plans are under way to install equipment to initiate incubation studies. An incubator and a refrigeration unit for a cold room were purchased, but final installation awaits some revision in the electrical supply.

RESEARCH PROGRAM

MANAGEMENT

Wide variations in climate, temperature, and altitude in different regions of Colombia require the study of management systems applicable to the differing locations. For this reason similar series of management studies have been initiated in the cold climate (Tibaitatá) and warm climate (Palmira).

One study, completed in 1961, of different housing systems in the cold climate revealed that best egg production and feed efficiency were obtained with hens raised in floor pens as compared with hens in community or individual cages (Table 1). Mortality, however, was lowest with hens in individual cages. The poor results obtained with hens in community cages were largely due to a serious incidence of cannibalism. Before results such as these are considered conclusive, further studies with larger numbers of hens and adequate control of cannibalism will be necessary, as well as studies of the relationship between management during the growing period and subsequent egg production.

In a similar study now under way at the warm climate station, and completed through 12 weeks, pullets raised in batteries show more rapid growth and greater efficiency than those being raised in floor pens. This experiment will be continued through 1962 and 1963 to determine the relationship between these two housing systems and egg production.

It is generally recommended that hens be supplied with about 14 hours of light per day to obtain a high rate of egg production. In Colombia the natural day-length of 12–13 hours throughout the year is slightly less than the recommended amount. Preliminary experimental results in the warm climate with the heavy breeds show that egg production and feed efficiency during the first six months of laying are greater when day-length is extended by at least one to two hours with artificial lighting. Further studies of this nature are in progress and include greater variations in day-length, light breeds of hens, and responses at higher elevations.

A study initiated in 1960 at Palmira on the influence of month of hatch on subsequent egg

TABLE 1.

Comparison of housing systems for laying hens.

Type of housing	Egg production Dec.'61–June'62 (%)	G. feed per egg	Mortality (%)
Floor pens	48.1	200.2	10.0
Individual cages	43.7	246.6	5.7
Community cages	38.1	276.8	15.5

production is being continued. However, owing to the nature of this study results will not be available until its termination in 1962.

NUTRITION

A broad series of investigations on the use of Colombian feedstuffs in broiler rations was initiated with 2,000 chicks. The feedstuffs studied were two types of corn, milo, soybean oil meal, sesame meal, cottonseed meal, alfalfa, coffee by-products, fish meal, and meat scraps. These experiments were designed mainly to test the comparative value of these ingredients as sources of protein and energy, and to determine relative efficiencies and costs for the various rations.

In a separate study at Tulio Ospina, 5% fish meal was found adequate to supplement a simple soybean-corn type diet containing no added amino acids or meat scraps. Higher levels of fish meal were of no further value. It has been observed, however, that Colombian fish meals bought on the market vary extensively in color, texture, and analysis. Since a great potential exists for the use of Colombian fish meals in local feeds as well as in the world market, it is hoped that extensive studies can be made of fish meal production and processing methods and their relation to the use of fish by-products in poultry feeding. This would involve further investigations of protein, amino acid, vitamin, and mineral adequacies of fish meal for poultry rations.

In another investigation a study was made of the use of high levels of antibiotics in diets for pullets and hens raised in the warm climate. Rate of gain and feed efficiency of pullets on range were greater when antibiotics were included in the diet. When pullets were moved to the laying house, however, those receiving antibiotics showed no further advantage in egg production, mortality, or efficiency. These preliminary results suggest that inclusion of antibiotics in rations may lower feed costs during the rearing period but have no effect on productiveness during the laying period. However, further studies with lower levels are needed.

In a short-term trial conducted in the warm climate with yearling hens, no beneficial effect on egg production, egg weight, or specific gravity of eggs was noted from the inclusion of ascorbic acid or zinc sulfate in commercial type laying rations containing corn, soybean oil meal, and fish meal as the major ingredients.

Checking fertility of incubated eggs from pedigree hens, Tibaitatá.

A second trial on the use of various coccidiostats, similar to that reported for Tulio Ospina in 1960, was made with broiler chicks. As observed previously, no incidence of coccidiosis was encountered in the untreated control lots, an indication that this poultry station continues to be free of this disease. The relative effect of the four coccidiostats studied on growth rate was similar to that reported in 1960 and confirms those results. Although relative differences between treated groups were similar, weight gains of chicks receiving the drugs were lower in relation to control lots than was observed in 1960. Since similar diets and the same strain of chicks were used both years, these differences between experiments may indicate an interaction with environmental conditions. Further studies of this nature, using chicks infected with the disease, are planned.

LABORATORY STUDIES

As a part of laboratory studies, a project was initiated to make complete analysis of the feedstuffs available in Colombia. For these studies a "sample bank" has been created in which selected samples of representative feedstuffs used in Colombia are set aside until a complete analysis is obtained. It is hoped that the results of these studies will supply animal nutritionists with a well-defined table of feed composition for use in Colombia. It is anticipated that the cooperation of other laboratories will be needed for certain analyses, and means for this are being investigated. All animal programs are cooperating in this study.

A Hampshire ewe and her lamb at Tibaitatá.

Sheep

The great demand for fine wool suitable for the textile industry, which has resulted in the importation of approximately 3,500 tons of wool at a cost of some 60 to 65 million pesos yearly, has brought about the realization by the government and people of Colombia of the potential benefits from improving domestic sheep production.

The mixed breed sheep of Colombia known as Criolla make up the major portion of the sheep population. These animals reputedly have developed a certain resistance to the many parasitic diseases present in the country, but both wool and meat production from these animals is low, and the wool is of inferior quality.

According to *Economía Grancolombiana* published in October, 1959, the per capita food consumption in Colombia for 1958 was 2,400 calories daily. Of this, one-sixth or 400 calories was supplied by animal products such as meat, milk, eggs, and fish. However, this is an average of the entire country and does not reflect the lower daily consumption of meat by a large group of people. The majority of these people live in small towns where the larger percentage of all lamb and mutton produced is consumed.

The development of the sheep industry through improved breeding, management, nutrition, and parasite control can help to reduce wool imports and to increase meat production in regions where it is most needed.

BREEDING

Sheep improvement in Colombia began only a few years ago. The sheep breeding program is dedicated mainly to the development of breeds well-adapted to local conditions which will produce wool of a quality and fineness suitable for the textile industry. This program was strengthened in 1960 by the importation of small flocks of Rambouillet, Corriedale, Romney Marsh, Hampshire, and Suffolk. These flocks were entered into breeding, selection, and adaptation studies in August, 1961, and a few lambs are on the ground at present. However, complete data on lambing, weaning, and wool production will not be available until July, 1962, and only preliminary results can be presented.

During the breeding season that began in August, 1960, 73 crossbred Romney Marsh ewes were entered into breeding at Tibaitatá. Fifty-four or 74% of these ewes dropped a total of 59 lambs with an average birth weight of 3.1 kg. Mortality from birth to weaning was 32.2%, an excessively high rate which was the result of an outbreak of an undiagnosed infectious disease. Thirty-nine of these lambs attained an average body weight of 26.1 kg. at weaning (132 days) and showed an average daily gain from birth to weaning of 0.176 kg. As commonly observed, the rams were heavier at weaning than the ewes, 27.3 kg. as compared with 24.9 kg. During the first 150 days of life, these 39 lambs produced an average of 1.34 kg. of wool each—more and of finer quality than is commonly produced by an adult of the Criolla breed in a complete year.

A total of 390 ewes of four breeds were entered in breeding studies at San Jorge during the year. The 304 or 77% of these ewes which lambed produced a total of 332 lambs for a lambing percentage of 85%. The average birth weight of the lambs was 4.05 kg. It is of interest that the 304 ewes that lambed produced only 28 sets of twins. A summary of lambing data by breeds is presented in Table 1.

Data on raw wool production from crossbred Romney Marsh ewes obtained during several years, according to number of lifetime shearings, show that the heaviest wool clip and longest staple length were obtained from the third and fourth shearings. After four shearings there is a small but steady decline in both wool production and staple length.

In 1961 the average wool clip for 231 adult Romney Marsh crossbred ewes was 3.63 kg. per head for an average growth period of 318 days. The average grade of this wool was 46 when classified by fineness of fiber according to the English system of classification. Average wool production and grade for the Rambouillet, Corriedale, and purebred Romney Marsh flocks for an average growth period of 229 days was 2.716 kg., 64's; 2.618 kg., 52's; and 3.643 kg., 46's, respectively.

PATHOLOGY

Sheep in all parts of the world are very susceptible to attacks by parasites, and probably suffer more severely from such attacks than any other class of livestock. The importance of parasites and parasitic diseases of sheep is even more evident in the tropical zones of the world. Since most of the more injurious internal parasites of sheep live in the animals' digestive organs, eggs of the parasites pass out with the manure and as a result pastures become contaminated. Pasture contamination is a special problem in regions where favorable conditions of warmth and moisture are ever present. In the temperate zone, parasite control is seasonal and is a problem mainly in the spring and summer months. With the arrival of extreme dryness and freezing, a large percentage of eggs and larvae of many parasites are killed, leaving the pastures almost free of infection. Climatic conditions in the regions of Colombia used for sheep production

A group of Corriedale and Rambouillet ewes with lambs at Tibaitatá.

are unfavorable for parasite control, and as a result internal parasites and parasitic diseases continue to be a very important problem in the development of the sheep industry.

All the parasitology and pathology studies at San Jorge were conducted by the two sheep husbandmen at the station. Each of the 770 head of sheep at the station was drenched an average of 20 times during the year in order to control the 13 different species of enteroparasites previously identified by the animal pathology section. Even with this intensive drenching program and pasture rotation, parasite infestation remained above a satisfactory level. At Tibaitatá, because of intensive stocking of the small pasture acreage available, parasite control presented an even greater problem than at San Jorge.

MANAGEMENT

The experiment to study the effect of interval of shearing on wool production was continued at San Jorge during 1961. One of the 3 groups of 25 ewes was sheared every 6 months, one every 9 months, and one every 12 months. According to results for the first 24 months of the 36-month trial, yearly wool production per ewe was increased by 0.239 kg. or 6% when wool production of ewes sheared at intervals of 6 months was compared with production of ewes sheared every 12 months. This increase is not sufficient to justify the additional shearing, and the common practice of shearing every 12 months continues to be the more economical system. Similar results were obtained when the six- and nine-month shearing groups were compared.

Flock management studies have been continued at San Jorge and Tibaitatá. Since parasite control continues to be one of the most important problems in the development of a sheep industry, future emphasis will be given to flock management as related to parasite control through improved pasture management and rotation practices.

NUTRITION

Pasture and forage crops represent the most logical and economical feedstuff for sheep and cattle in Colombia and since forage evaluation data are almost completely lacking for this region, digestibility studies with sheep were initiated at Tibaitatá during the year. Three trials were conducted to determine the apparent digestibility of the various nutrients in oat silage. The average composition of the oat silage, which was ensiled in the late dough stage, was as follows: 23.17% dry matter, 2.86% protein, 7.77% fiber, 0.92% fat, and 9.05% nitrogen-free extract. The digestion coefficients of these various components were: dry matter, 49.5%; protein, 51.0%; fiber, 53.7%; fat, 66.6%; and nitrogen-free extract, 47.7%. These results show a total digestible nutrient content of 11.33%. Future trials will be conducted to evaluate many of the economically important pasture and forage crops grown in the country.

TABLE 1.

Breeding efficiency of flocks at San Jorge.

Breed	No. of ewes	No. of ewes that lambed	Lambing %	Av. birth weight (kg.)
Rambouillet	47	39	93.6	4.215
Corriedale	23	18	91.3	4.063
Romney (crossbred)	272	221	87.9	4.311
Romney (purebred)	48	26	58.3	3.631
Total	390	304	85.1	4.055

Hampshire gilts on kikuyu pasture.

Swine

Swine production in Colombia is at an early stage of development as an industry. Until very recently the large swine farm was a rarity in Colombia and although still the exception, more are being developed in regions where feedstuffs are available. One or two head tied near the homestead continue to make up the greater part of the industry.

As an important part of the national economy of Colombia, the industry urgently needs to be improved through technical direction in nutrition, breeding, and management. To assist in this goal the national swine program is being developed with four main research projects: management systems; nutrition studies; breeding and selection; and physiological studies. The development of economical rations for swine is of primary importance in Colombia and therefore nutrition was given the most emphasis in the past year.

MANAGEMENT

It is important that swine farmers realize the necessity of producing large, healthy litters of pigs through the use of sound management practices. Improved management practices used at Tibaitatá during the farrowing and pre-weaning periods resulted in lower mortality, larger weaning weights, and larger litter weights at 56 days than produced last year. By the use of farrowing crates constructed of wood and by improving sow nutrition and management, mortality was reduced from 39.6% to 35.8% in the second farrowing, and further reduced to 26.0% in the third. These figures include all pigs that were born dead. At the same time weaning weights were progressively improved from 14.81 kg. in the first farrowing to 15.25 kg. and 17.19 kg. in the second and third, respectively. The higher weaning weights and lowered mortality improved 56-day average litter weights from 78.27 kg. in the first breeding experiment to 102.23 kg. in the second and to 119.29 kg. in the third. The greater efficiency was due in large part to better attendance at farrowing, stronger pigs at birth resulting from improved sow management and nutrition, and less crushing from the use of farrowing crates.

NUTRITION

TIBAITATA

Three nutrition experiments utilizing 184 pigs were concluded and a fourth utilizing 98 pigs was begun. An experiment to study the replacement value of milo for corn with growing-finishing pigs in confinement was conducted as the first in a series planned to develop rations utilizing energy sources other than corn. Since energy grains or carbohydrate constituents comprise more than 75% of the ration for growing pigs, corn at its present price is economically marginal as the main energy source. In this corn-milo experiment differences in rate and efficiency of production were very small among groups receiving the corn, milo, or corn-milo base diets, with an over-all average daily gain of 0.885 kg. and feed efficiency of 3.72 when carried to an average market weight of 105.4 kg. The greater rate of gain (0.914 kg. per day) was obtained by the use of a 50-50 corn-milo mixture. These results show that clean-grain milo can be used without loss of production to replace all or part of the corn in growing-finishing rations.

Another study concerned the use of sesame meal, fish meal, and soybean oil meal in growing-finishing pig rations. Sesame meal at levels of 5% and 10%, incorporated into corn base diets containing 4% fish meal and sufficient soybean oil meal to produce a diet containing 16% total protein, supported gains equal to those produced by the soybean oil meal-corn-fish meal diet. Differences in feed efficiency were small among the various groups.

A second experiment in the series planned to evaluate protein sources and to further evaluate sesame meal as a ration protein was recently started. The data will be presented in next year's report.

Since a large portion of the commercial swine production is based on the use of commercially mixed feeds, a small trial was conducted to compare two commonly used commercial rations and a standard corn-soybean oil meal diet. The standard diet supported gains equal to 0.89 kg. per day on 3.49 kg. of feed over the 84-day experiment period. One of the commercial diets supported almost equal gains of 0.87 kg. per day on 3.43 kg. of feed; however, the second only supported gains equal to 0.74 kg. per day on 4.10 kg. of feed. These results show the extreme care that must be employed by the swine producer in selecting commercial rations, and also indicate the need for improved commercial feeds.

Farrowing crate constructed and used at Tibaitatá to reduce baby pig mortality.

PALMIRA

A trial to study the value of milo as a replacement for corn for growing-finishing pigs in confinement was conducted at Palmira. This was a replication of the Tibaitatá experiment and although the over-all growth rate was slower, comparisons among treatments were similar, with only very small differences in rate and efficiency of gain.

A replication of the Tibaitatá experiment to evaluate sesame meal, soybean oil meal, and fish meal as ration proteins for growing-finishing swine in confinement constituted the second nutrition experiment at this station. Again results among treatments indicated that sesame meal can replace a portion of the soybean oil meal in the diet without significantly reducing gain or feed efficiency. As in the experiment above reported, over-all average growth rate was slower than reported at Tibaitatá. The lower average growth rates observed at Palmira appear to be the result of differences in altitude and climatic conditions (Palmira, 1,000 m. altitude and 75°F. average temperature vs. Tibaitatá, 2,600 m. altitude and 57°F. average temperature). However,

TABLE 1.

Performance testing data on Duroc swine selected for herd improvement, Tibaitatá.

	No. animals	BIRTH	WEANING	Av. daily gain to weaning (kg.)	5 MONTHS		Av. daily gain, weaning to 5 months (kg.)
		Av. wt. (kg.)	Av. wt. (kg.)		Av. age (days)	Av. wt. (kg.)	
Gilts	7	1.23	19.07	0.319	155	104.14	.858
Boars	6	1.26	21.35	0.359	147	102.25	.889
Both sexes	13	1.24	20.12	0.337	151	103.27	.875

since different strains of the same breed are used at these stations, strain differences may be a factor worth considering.

Breeding and Selection

TIBAITATA

The program for the improvement of the Duroc and Hampshire herds was continued at this station. The purpose of this work is to obtain lines of animals selected for high rates of gain and feed conversions and to obtain uniform animals for use in nutrition and other experiments. A method of herd selection is being employed whereby only performance-tested gilts and boars from high-producing parents are selected for herd replacements.

A total of 38 sows and gilts farrowed at this station during the year, producing a total of 373 pigs, 37 of which were stillbirths. At 56 days, 254 were weaned with an average weight of 16.5 kg. Even though mortality has gradually been reduced by the use of better management, breeding, and feeding practices as indicated in the section on management, the 24.5% over-all mortality from birth to weaning at 56 days reflects the almost complete lack of farrowing and raising facilities.

The basis of any selection program must be the individual record of an animal plus the record of its offspring. To develop a high producing herd, emphasis has been placed on birth weights, weaning weights, and performance testing data based on weight and average daily gains from weaning to about five months of age. A summary of these data for animals selected as herd replacements is given in Table 1. These data compare well

Duroc pigs in nutrition trials reached a market weight of 100 kg. in five months.

with performance data reported in many parts of the world.

PALMIRA

One breeding experiment was completed at this station which involved a total of 11 sows and gilts. Ten of these animals farrowed 98 pigs or an average litter size of 9.8 pigs. Mortality was very high because of an outbreak of mastitis and only 6.1 pigs per litter were weaned at an average weight of 15.83 kg. The high incidence of mastitis reflects the effect of raising swine in lots and corrals which are undesirable for swine production.

Veterinary Science

The veterinary science program has made significant advances during the past year. These include the servicing of clinical cases, the initiation of various studies of livestock diseases, and the completion of the detailed plans of the veterinary research and graduate training laboratory in Bogotá.

RESEARCH LABORATORIES

The plans for the veterinary research laboratory contracted by DIA to be built in Bogotá were completed in 1961. The drawings include architectural, construction, and engineering plans, together with detailed specifications and the construction contract. Lists of basic equipment, furniture, personnel, and organization have been prepared. This represents considerable effort by many people over the past three years, including consultants sent to the United States to study similar laboratories. It is hoped that it will be possible to construct this laboratory in the immediate future.

The Faculty of Veterinary Medicine and Animal Husbandry has made a detailed and critical study of its undergraduate training and facilities. Consultants for this study were Dr. William Pritchard, head of the Department of Veterinary Science, University of Florida, and Dr. Kenneth Turk, head of the Department of Animal Husbandry, Cornell University. The final report recommended augmentation of the physical facilities and staff, additional farm practice for both veterinary and animal husbandry students, and the separation of animal husbandry from veterinary science after two years of basic training. The Faculty is actively implementing many of the suggestions and it is expected that more will be possible in the future when the physical improvements are realized. This review and the subsequent report will probably influence the development of other schools in South America, for many of the suggestions are applicable throughout the hemisphere.

The architectural and most of the construction plans for the regional research laboratories at Palmira and Turipaná have been completed by the engineering section of DIA. These are simple buildings employing standard metal components which can be started in the immediate future.

These three laboratories and their staff represent the research centers of the program. Until they are completed, veterinary medical research is limited to projects which can be conducted in the small service clinics.

SERVICE CLINICS

Three clinics, Tibaitatá, Palmira, and Montería, had resident veterinarians during the past year, and Armero for part of the year. The remaining seven clinics were unstaffed because of the lack of personnel. Though recording was not complete, a total of 73,142 recorded service functions were performed (Table 1).

The diagnoses made during the past year (Table 2) indicate the principal pathologic conditions encountered in Colombia. Parasitism of the intestinal or pulmonary types, or in the blood, together with nutritional and bacterial enteritis constitute the major problem in rearing all types of young animals, as demonstrated by a combined incidence of 950 clinical cases.

The occurrence of trichomoniasis in the breeding bulls of the beef herd at La Libertad in Los Llanos necessitated the complete cessation of genetic studies there, since this parasite is venereally spread. Prompt identification of infected animals, their disposal, and the isolation of remaining animals prevented a spread of the infection and permitted resumption of breeding after seven months.

The occurrence of six fatal cases of altitude disease (Mal de Alturas, brisket, or edema disease) in the acclimatized cattle at Tibaitatá represents a 2% incidence. If this same incidence occurs in all cattle in the Savannah it represents a loss of approximately 12,000 head annually. Extensive studies are in progress on this disease, as reported below.

TABLE 1.

Clinical services performed by the veterinary science program, 1961.

Services	No.
Vaccinations	31,201
Control of external parasites (baths, dips, sprays)	14,118
Control of internal parasites (drenches, purgations)	18,923
Laboratory examinations[a]	5,171
Surgery	1,048
Disease diagnoses (mammal, avian)	2,681
Total	73,142

[a] Immunological tests (brucellosis, tuberculosis, pullorum, etc.), blood, fecal, urine, and bacterial examinations, animal inoculations, histopathologic slides, miscellaneous examinations.

RESEARCH

ALTITUDE DISEASE

Initial studies indicate that this physiologic condition occurs in cattle which fail to adapt to high altitudes. Interestingly, it occurs both in imported cattle and in cattle born at the altitude of the Savannah. The exact cause is not known but it probably consists of a complex including faulty hemodynamics, increased pulmonary resistance, and vascular changes resulting in the production of classic chronic venous congestion and right heart hypertrophy. The studies have been handicapped by the lack of known normal values at the altitude of the Savannah. Such values are now being accumulated and are being compared with clinical cases of altitude disease. Many of the medical space-flight data are directly applicable to these studies.

BRUCELLOSIS

Studies initiated in the Savannah in 1960 which revealed a 26.98% incidence of bovine brucellosis were extended to the milk-shed of the Cauca Valley. The incidence of reactors in the Valley was 8.84% or roughly one-third that of the Savannah.

VIBRIOSIS

Six Holstein herds in the Bogotá milk-shed and six in that of Cali were tested for *Vibrio fetus* infection by the blood-serum agglutination test. The herds averaged 30 to 40 animals, were under better than average management, and were dispersed through the Savannah and Valley. Thus they more accurately indicated the incidence of vibriosis in the Holstein herds. All herds tested were positive, averag-

TABLE 2.

Summary of mammalian diagnoses conducted on animals by the veterinary science program, 1961.

Abortion (various)	16	Hydrocele	1
Abscesses	36	Intestinal parasitism	137
Acetonemia	1	Hypopyon	4
Actinomycosis	5	Injuries	103
Agalactia	1	Keratocele	1
Alopecia	2	Keratitis	20
Altitude disease (brisket or edema disease)	6	Leukoma	3
Anaplasmosis	24	Listeriosis	8
Anemia (various)	9	Lung worm (*Dictyocaulus viviparis*)	77
Anthrax	1	Malnutrition	12
Arthritis	22	Mastitis	83
Asphyxia	3	Metritis	18
Avitaminosis A	1	Metroperitonitis	1
Avitaminosis B	1	Miasis	137
Blackleg	8	Nephritis	2
Blepharoconjunctivitis	1	Neoplasms	5
Bloat	39	Neuritis	1
Bronchitis	6	No diagnosis	9
Bronchopneumonia	50	Omphalitis	24
Cachexia	13	Orchitis	1
Cervicitis	1	Otitis	48
Coccidiosis	194	Paraphimosis	1
Colic	19	Parotitis	2
Conjunctivitis	73	Paraplagia	1
Corneal ulcer	1	Phimosis	1
Dermatitis	1	Photosensitization	1
Dystocia	8	Piroplasmosis	2
Ecthyma	1	Pneumonia	28
Enteritis (nutritional)	314	Posterior paralysis	1
Enteritis (infectious)	202	Prolapsed uterus	2
Enterorrhagia	3	Purpura haemorrhagica	1
Exanthema	10	Rabies	1
Enterotoxemia	8	Retained placenta	46
Exophthalmia	1	Rickets	17
Foot-and-mouth disease (Aftosa)	201	Septicemia haemorrhagica	40
Foot rot	88	Strangles	9
Funiculitis	1	Tracheal obstruction	2
Goitre	4	Trichomoniasis	5
Gonitis	4	Trypanosomiasis	5
Hematoma	2	Shock	2
Hepatitis (necrotic)	2	Vaginitis	5
Hernia	3	Vulvitis	1
Hog cholera	2	Warts	39
		TOTAL	2,297

ing 24.4% reactor animals. This high incidence, previously unknown, represents a severe if not principal loss to dairymen in the form of delayed conceptions, multiple services, and abortions, all resulting in a reduced milk yield. This loss may be aggravated by brucellosis, trichomoniasis, and poor breeding records. Frequently in the absence of accurate farm records, poor, nonproductive cull cows are kept in the herd.

The veterinary science program is cooperating with the owner of a commercial herd to demonstrate methods of control and improved management, and at the same time is obtaining additional research material. Results have been most encouraging. To study vibrionic abortion further, test antigen is being prepared locally and will be available for use by other interested investigators.

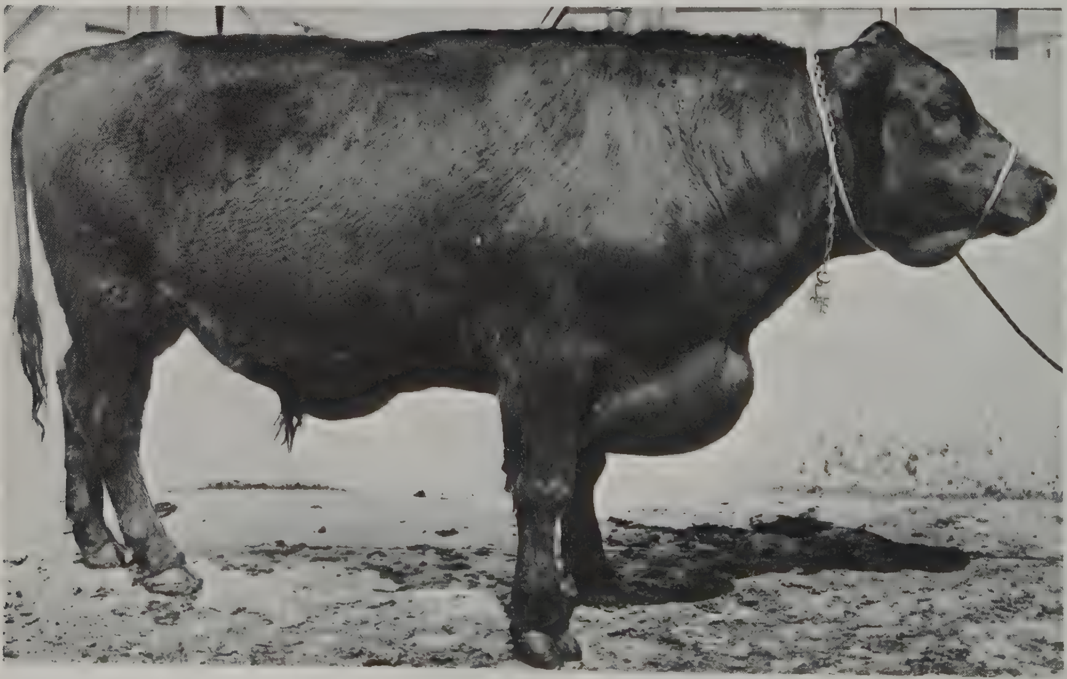
CALF SCOURS AND ENTERITIS

Studies continuing at Montería-Turipaná indicate that the most common bacterial agent causing enteritis in calves is *Escherichia coli*. Unsanitary crowded conditions and poor management favor this form of calf enteritis.

Five types of coccidiosis have been found to occur in the Montería-Turipaná district: *Eimeria zurnii*, *E. bovis*, *E. ellipsoidalis*, *E. subspherica*, and *E. aubernense*. *E. zurnii* is the most frequent and severe. Various field control methods for bovine coccidiosis are being studied. To date no completely effective control is known. There is a great need for the development of an effective drug by the pharmaceutical industry; it would have worldwide application and benefit.

OTHER STUDIES

Several studies, including those on bovine tuberculosis, mastitis, *Dermatobia hominis*, bloat, leptospirosis, and others, have been delayed. It is important that these be reactivated, particularly the one on leptospirosis. Earlier studies on leptospirosis indicated widespread occurrence in the Savannah, where it affects much of the livestock and also occurs in the human population. Cer-



A purebred Aberdeen Angus bull born on the Savannah, suffering from altitude disease. Compare with normal animal (p. 185).

tainly the temperature and the abundance of slow-moving canal water used and contaminated by livestock and human beings alike present an ideal environment for the growth and dissemination of leptospirae.

The Veterinary School in Quito, Ecuador, was visited during the past year. The visit was made to assist in their development program and to explore the possibility of cooperative research. The latter appears feasible and it is planned that the incidence of vibriosis in cattle near Quito will be studied.

Typical new shop building.

Farm Administration

The engineering section was strengthened during the past year by the addition of one civil engineer, one architect, and two draftsmen. The principal efforts of the section have been concentrated at Turipaná, Palmira, La Libertad, and Tibaitatá, while other projects have been carried on at other locations.

Construction and Field Improvement

The following is a list of the projects completed or in progress at experiment stations during the year.

TURIPANA

(1) A supply warehouse of 500 square meters has been completed.

(2) A farm shop building of 600 square meters and two machinery sheds with a total area of 900 square meters are nearing completion.

(3) A house for the station director has been started.

(4) A scale model and plans of the building to provide dormitory, kitchen, and recreational facilities for professional personnel were made.

(5) A box culvert was built under the road separating the main part of the farm from the river.

(6) A 480 gallon per minute well, equipped with a diesel driven pump, has been completed. The water from this well will require treatment before it is completely potable and a study of the necessary treatment is being made.

(7) The surveying and mapping necessary for current road and drainage work was done.

(8) Approximately 7,000 cubic yards of first-quality building sand was hauled from the Sinú River during the dry season and stored on the farm for use in the construction program.

PALMIRA

(1) Approximately 1.5 miles of road were built and surfaced.

(2) A drainage canal 1 mile in length was completed.

(3) A 1,100 gallon per minute well, equipped with diesel driven pump, was completed.

LA LIBERTAD

(1) A plan of the entire farm with land division, roads, drainage, and building locations was made.

(2) Detailed plans were made for farm shops, supply warehouse, and a building to supply dormitory, kitchen, and recreational facilities for professional personnel.

(3) Provisional kitchen and dormitory facilities for professional personnel were constructed.

(4) Approximately 45 acres of jungle have been cleared and 1.5 miles of road have been constructed.

TIBAITATA

(1) A mezzanine was constructed in the grain storage building with offices and a seed laboratory for the small grains section.

(2) A hog farrowing barn 30 × 120 feet has been completed.

(3) A power station to house generators of 600-Kw. capacity is under construction.

(4) Some progress has been made on insulating and installing refrigeration equipment in the potato storage.

(5) One 140-ton capacity silo was completed in the beef cattle section.

NATAIMA

(1) A machinery shed of 250 square meters was completed.

(2) A supply building of 250 square meters was completed.

(3) A complete road system was built and surfaced.

OBONUCO

(1) Three buildings were completed for the dairy section and work continues on several others.

ARMERO

(1) Three trench silos are under construction.

(2) A total of 455 acres was mapped.

SURBATA

(1) A farm supply building of 250 square meters was completed.

MACHINERY

Nine new tractors were purchased, five old machines were disposed of, and several machines were rebuilt.

One D-7 bulldozer and one heavy dump truck were added to the heavy machinery pool.

To give more mobility to the heavy equipment, a second-hand 20-ton trailer and tractor were acquired. This machinery is being overhauled.

Field day, Palmira.

Agricultural Information

Agricultural information work in Colombia is in its infancy. There is no established profession of agricultural journalists nor is there a large group of extension information specialists, though both types of trained individuals are greatly needed. The problem of information flow between research stations and extension workers is one of the biggest roadblocks confronting agricultural progress in Colombia today. Few extension workers visit the experiment stations as a matter of routine to keep up with research findings, and as a result the investigators at the stations are deprived of an important source of information about the problems faced by farmers.

Progress toward cooperation between investigation and extension was made with the establishment of an information program in DIA in October, 1961. During the remaining months of 1961 the program was chiefly concerned with organizational arrangements.

Informal talks with representatives of magazines and newspapers indicate that many possibilities exist for publishing research stories and pictures. Photographs and transparencies are used by every program in DIA and there is a need for expanded services.

Equipment was redistributed between laboratories and new items were purchased where needed. New slide and 16-mm. movie projectors were purchased and two old projectors were sent in for repair. It is planned that every experiment station will eventually have projection equipment and trained operators to make use of movies and transparencies produced by the information section.

At one field day held in November at the Nataima station, interviews conducted with 89 visitors produced the following information: this was the first visit to the experiment station for 52 visitors; of the remaining 37 visitors, every one had previously visited the station at least twice; 32 visitors owned an average of about 94 hectares each, nine rented an average of 112 hectares to other farmers, and 19 rented an average of 78 hectares each from other property owners; the visitors to this one field day represented approximately 5,505 hectares of farm land in the immediate vicinity of the experiment station.

Exhibition equipment was ordered and plans are under way to begin production of exhibits for use in field days and agricultural fairs. This, coupled with an improved photographic section, should add new emphasis to information dissemination from DIA.

Chilean Agricultural Program

Personnel

CHILEAN AGRICULTURAL PROGRAM

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Mario Rogers Moreno, ING. AGR., Secretary General, Department of Agricultural Research
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Alejandro Violic Martinovic, ING. AGR., Director, South-Central Experiment Station, Chillán (on leave)
Alfredo Mathieu Köhler, ING. AGR., Director, Southern Experiment Station, Temuco

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Juan Eduardo Lira Vergara, Student in Training, Central Experiment Station, Santiago

Fernando Nome Huespe, Student in Training, Central Experiment Station, Santiago

Hernán Tejeda S., Student in Training, South-Central Experiment Station, Chillán

FORAGE AND PASTURE PROGRAM

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Paul J. Fitzgerald, PH.D., Geneticist, The Rockefeller Foundation

Melvin G. Greeley, PH.D., Assistant Animal Scientist, The Rockefeller Foundation

Royse P. Murphy, PH.D., Temporary Staff Member, Consultant on Forage Improvement

Hiram Grove Valenzuela, PH.D., Head, Forage Program

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Santiago Margozzini Roca, Student in Training, Central Experiment Station, Santiago

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Hernán Rivadeneira Arenas, Student in Training, Central Experiment Station, Santiago

Jaime Sepúlveda Alegría, Student in Training, Central Experiment Station, Santiago

Alicia Vergara Scarbourough, Student in Training, Central Experiment Station, Santiago

EXPERIMENT STATION OPERATIONS

Arthur D. Leach, Jr., PH.D., Associate Agricultural Engineer, The Rockefeller Foundation

Oscar Lillo Valladares, Architect (temporarily assigned to the Office of Special Studies)

Michael Raczynski von Oppen, ING. AGR., Assistant Agronomist, Central Experiment Station, Santiago

Horacio Urzúa Sotomayor, Student in Training, Central Experiment Station, Santiago

Eugenio de Marchena Guzmán, Student in Training, Central Experiment Station, Santiago

Construction of the station warehouse, Santiago.

Director's Introduction

The determination on the part of the Chilean Government to raise production of basic foods is reflected in the expanded support for the development of the new regional research stations at Santiago and Temuco. For the period 1962–1964 a total of Eo 1,700,000 (U.S. $1,200,000) has been appropriated for the physical plant, which includes installations for both agronomic and animal research. Construction of the research laboratories and offices at the Central Experiment Station in Santiago is nearing completion and the first three units of the animal nutrition center, namely, the metabolism laboratory, beef nutrition barn, and the clinic, are scheduled for 1962. At the Southern Experiment Station near Temuco, final building plans are ready for the construction of the research laboratories and offices, as well as of the first three units of the animal nutrition center.

After three years of testing, the new wheat varieties Orofén 60 and Chifén have been released for increase of registered seed. The former, a selection from the improved wheat Orofén, is adapted to the north-central irrigated wheat zone and yields about 10% more than the original variety; the latter, also a selection from Orofén, is the first variety developed by the Office of Special Studies for the intermediate wheat region, where neither the spring wheats of the north nor the winter wheats of the south are very well adapted.

Two new forage varieties released by the Office of Special Studies last year are in large-scale certified increase. It is expected that approximately 1,000 hectares of the red clover variety Quiñekeli will be grown for certification this year. This will produce enough seed to meet the national needs after one further increase in 1963. In the case of the improved alfalfa variety Ligüen, about 500 hectares can be sown for certification this year, giving sufficient seed to meet the commercial demand after one additional increase. It is estimated that these two varieties will replace the present ones on at least one-half of the acreage now planted to alfalfa and red clover, or on approximately 625,000 acres; and that the superior yields which can be expected will represent a monetary value of more than Eo 7,000,000 (U.S. $5,000,000) annually. To ensure that ample seed of good quality reaches the farmer as soon as possible will require that more personnel be trained in seed production and certification. The problems of dodder infestation and insect damage in seed fields need urgent study. Likewise, extension efforts to promote better pasture establishment and management practices will have to be greatly augmented, if the yield potential of the improved varieties is to be realized. It has been shown, for example, that annual applications of fertilizer on pasture, a practice at present used only infrequently, results in substantial increase in yield and should be more widely employed.

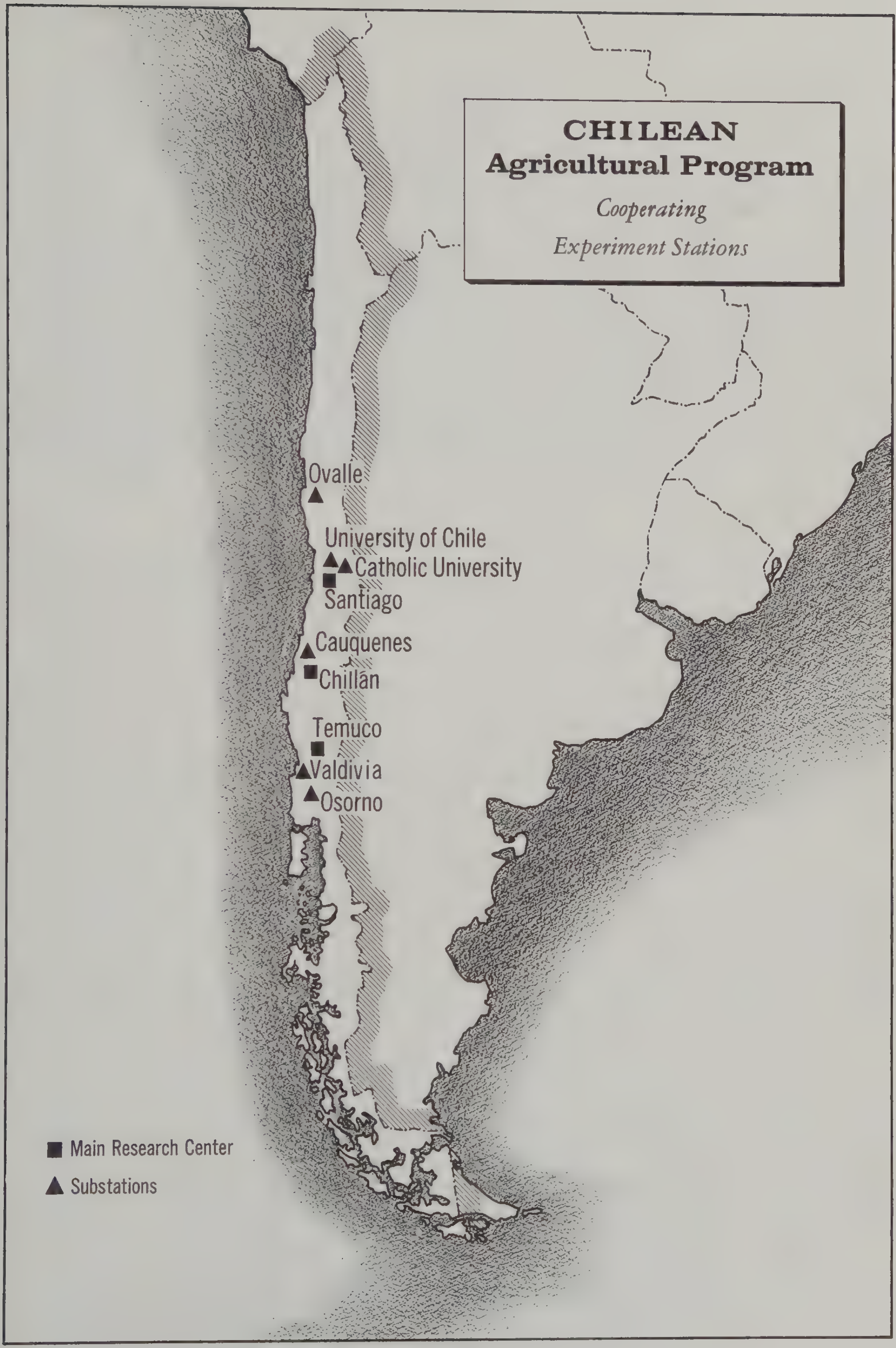
After three years of grazing trials conducted in cooperation with the University of Concepción at Chillán, the results show an average production of over 1,200 kilograms of beef during the grazing season (September through May) without supplemental feeding. If a yield of only 50% of that obtained in these experimental trials were attained commercially on 500,000 hectares with adequate moisture, the national meat deficit could be eliminated. This goal does not appear unreasonable when it is considered that an estimated 15,000,000 hectares, mostly dryland and mountain range, are in permanent use for the production of livestock.

Dr. Donald L. McCune left the forage program in February, 1962, to accept a position with the Tennessee Valley Authority. Under his direction and in the short space of three and a half years, the forage project made notable progress, culminating in the development of the red clover variety, Quiñekeli, and the alfalfa variety, Ligüen.

The recent appointment of Animal Nutritionist Dr. Melvin G. Greeley to the staff will permit greater emphasis on determining the most efficient methods of forage utilization. Until the Central and Southern Experiment Stations are completed, work will be conducted at Chillán, Los Angeles, and Osorno, where existing facilities are adequate for preliminary studies.

Dr. Royse P. Murphy, Head of the Department of Plant Breeding at Cornell University, is finishing a year's appointment as a temporary staff member. His valuable assistance in the general orientation of the research program and in training personnel and students is gratefully acknowledged.

During the past year a total of 41 student trainees gained experience in practical field research through participation in the various aspects of the program.



CHILEAN
Agricultural Program
Cooperating
Experiment Stations

Chilean Agricultural Program. Cooperating Experiment Stations.

	Location	Size (acres)	Altitude (feet)	Av. temp. (°F.)		Av. rainfall (inches)	Soil types	Principal fields of investigation	Type of agriculture in region served
				Jan.	July				
MINISTRY OF AGRICULTURE STATIONS									
Central Experiment Station	Santiago	753	2,064	69.1	46.4	15.6	Non-calcic Brown; Alluvial	Corn, cereals, beans; Forage crops; Oil crops	Crops; Fruit; Livestock; Dairy (Irrigated)
Substation	Ovalle	250	797	67.6	52.0	5.1	Calcic Brown; Alluvial	Cereals	Dryland farming (Supplementary irrigation)
Substation	Cauquenes	1,500	472	71.8	48.2	28.0	Reddish-brown Laterite	Range management	Dryland farming
Southern Experiment Station	Temuco	555	1,056	62.6	46.0	53.0	Alluvial; Volcanic Ash (Trumao)[a]	Cereals, potatoes; Forage crops; Oil crops; Soil fertility	Crops; Livestock; Dairy (Supplementary irrigation)
Southern Region Substation	Osorno	325	75	63.7	46.7	52.5	Trumao	Cereals; Forage crops	Crops; Livestock; Dairy (Dryland)
MINISTRY OF AGRICULTURE—UNIVERSITY OF CONCEPCION									
South-Central Experiment Station	Chillán	750	374	71.4	48.4	40.5	Trumao with Grumosol inclusions	Corn, cereals; Forage crops; Oil crops; Animal nutrition	Mixed farming (Supplementary irrigation)
UNIVERSITY STATIONS									
University of Chile	Santiago	3,000	1,476	69.1	46.4	14.3	Non-calcic Brown	Corn, cereals, fruit; Forage crops; Dairy science	Mixed farming (Irrigated and dryland)
Catholic University	Santiago	750	2,182	69.1	46.4	19.7	Non-calcic Brown (modified)	Corn, cereals; Forage crops; Poultry; Dairy science	Mixed farming (Irrigated)
University of the South	Valdivia	375	43	62.8	46.0	99.0	Trumao	Potatoes; Forage crops	Crops; Livestock; Dairy (Dryland)

[a] The "Trumao" soils of southern Chile are similar to the Ando soils of Japan, the Yellow-brown Loam of New Zealand, and some of the volcanic formations in Oregon, U.S.A.

Evaluation of wheats prior to harvest.

Wheat

Coincident with the growth of the regional experiment stations, the wheat project has evolved as three closely coordinated but semiautonomous units, each representing an important wheat region of Chile. Research is conducted at the regional level where the environmental factors involved in wheat production are intrinsically different. Objectives or problems common to more than one region are approached in the one where they may be studied best.

A summary of the results of yield trials conducted during 1959–1962 at the principal experiment stations is presented in Table 1.

NEW VARIETIES

Two new spring wheat varieties have been released this year, Orofén 60 and Chifén. The first variety is for use in the northern wheat zone, and the latter is recommended for spring or late winter plantings in the intermediate and southern wheat zones. The varieties Nortefén and Primafén, also in multiplication this year, were judged to have inadequate rust resistance and so have been withheld.

Orofén 60 is a recent selection from the same cross which produced Orofén (Newthatch/Marroqui-Kenya/Mentana × Frontana), the first variety released by the Office of Special Studies. It is phenotypically similar to Orofén, but has consistently yielded about 10% more in test plots and is expected to replace Orofén in its area of cultivation. Fifteen tons of foundation seed of Orofén 60 were turned over to the Seed Multiplication Section of the Ministry of Agriculture; an estimated 6,000 tons of certified seed should be needed eventually. The increase of this variety, as well as of Chifén, is being conducted by the State Bank and the National Society of Agriculture.

Chifén, which is also derived from the same cross which produced Orofén, is the first variety to be produced by the Office of Special Studies for the intermediate and southern wheat regions, where it is recommended for spring seedings. Yields of up to 5 ton/ha. have been attained in the Chillán area and up to 4 ton/ha. in the Temuco area from spring seedings. Fall-sown Chifén yielded as much as the winter wheat Cappelle at Chillán this year. Chifén is resistant to stripe rust and moderately resistant to leaf rust, important characteristics for wheats to be grown in the south. Its resistance to stem rust, although inadequate for the north, is superior to that of the varieties grown in its recommended area. A primary goal of 1,500 tons of certified seed has been set for this variety. Of the 14 tons of seed turned over to the Ministry for further multiplication, 4 tons were classified as foundation seed. The rest will be released as registered seed.

SOUTHERN EXPERIMENT STATION

Wheat investigations centered at the Southern Experiment Station, Temuco, serve the important agricultural zone located south of Bio-Bio province. In this region, where the average annual rainfall ranges from about 40 inches to more than 95 inches with peak periods of rain during the winter months, wheat is almost universally grown without supplemental irrigation.

Since winters are mild by continental standards, extreme winter hardiness is not needed in fall-sown wheats. Frosts, however, may be frequent until December and in some sectors occur during each month of the year. For this reason, wheat varieties grown in the region should not head until late November or mid-December, to minimize losses caused by frost damage at the time of flowering.

As a class, varieties of French, Belgian, Dutch, and German origin are well adapted in this region. Varieties tested from Scandinavia ripen too late to be of direct use, although their otherwise excellent characteristics provide useful factors for hybridization. The winter variety Cappelle and the inter-

TABLE 1.

Summary of yields of wheat at three locations, 1959–1962.

Location and variety	Yield in ton/ha.			Average (% check)
	59–60	60–61	61–62	
Southern Experiment Station, Temuco:				
1940 Druchamp	2.84	4.89	5.88	108
Vilmorin 53	2.30	5.39	5.94	105
Pax Cambier	2.73	4.59	5.72	104
Cappelle (check)	2.70	4.51	5.30	100
Vilmorin 29 (check)	2.62	4.66	5.09	98
South-Central Experiment Station, Chillán:				
Yaktana 54 × Norin 10-Brevor[a]	—	5.52	4.39	140
Alter de Gembloux	—	—	4.39	137
Pax Cambier	—	4.43	4.25	122
Chifén (new variety)[a]	—	4.53	3.60	114
Cappelle (check)	—	3.90	3.20	100
Vilmorin 29 (check)	—	4.31	2.92	94
Central Experimental Station, Santiago:				
Orofén 60 (new variety)	6.20	3.40	5.58	117
Orofén (check)	5.03	3.28	5.23	105
Menflo (check)	4.66	3.06	5.21	100

[a] Spring wheats from spring seeding.

mediate variety Vilmorin 29 are the most widely grown in the region and are used as check varieties in the program.

Low soil fertility is a serious problem in this region. With adequate fertilization, however, yields of over 5 ton/ha. can be obtained economically with existing varieties and are not uncommon in parts of this zone. Average yields of more than 2 ton/ha. are reported for the provinces of Llanquihue and Osorno; these are among the highest in the country. The annual production in the southern wheat region amounts to more than 500,000 tons, or slightly less than half the total national production.

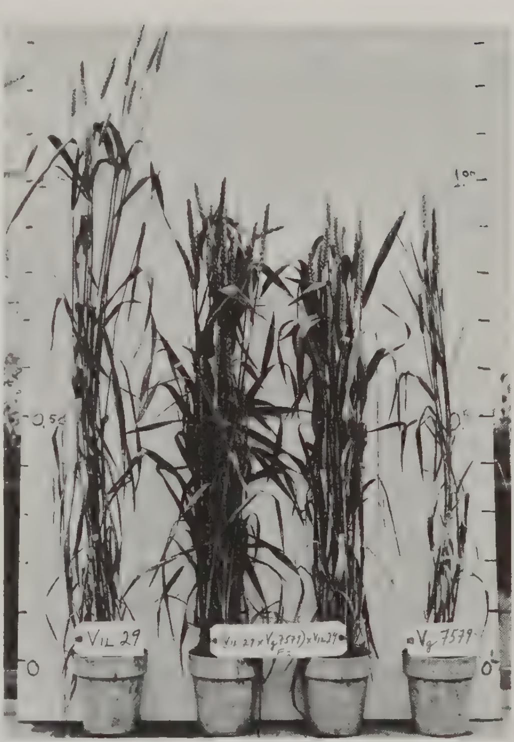
VARIETAL IMPROVEMENT

The development of better varieties for this region is based on evaluation of introductions from countries with wheats of proved adaptation and on extensive hybridization among a wide class of wheats. Emphasis is being given to the incorporation of stripe-rust and leaf-rust resistance, short straw, quality, yield, and proper maturity class. Stem rust occurs only very late in the season and is not considered a serious problem. None of the commercial varieties is resistant to either stem or leaf rust.

The winter wheat of French origin, 1940 Druchamp, has been chosen for multiplication. This wheat has yielded more than Cappelle in station trials conducted during the past three years and has performed well this year in off-station trials. In small plots grown at Valdivia, 1940 Druchamp yielded 7.2 ton/ha. compared with 6.6 ton/ha. for Cappelle.

Of the French wheats introduced in 1960 the varieties Elite Lepeuple and Maitre Pierre yielded more than Cappelle in this year's trials. Seed lots of these varieties will be increased while further performance data are accumulated.

Among the more than 2,600 new introductions evaluated this year, the best were a group of 48 winter wheats recently developed in France, Belgium, Holland, Germany, and New Zealand. These have been selected for yield trial comparisons in the coming season. A collection of over 900 winter wheats has been formed with the stripe-rust-resistant selections made in these introductions, and sent to Colombia for further screening against the biotypes of stripe rust in that country.



Well-adapted, short-strawed wheats (*center*) are produced by crossing the French variety Vilmorin 29 (*left*) with a semi-dwarf wheat from the State of Washington (*right*).

A number of interspecific crosses between a branched-spike *Triticum turgidum* and winter types of *T. aestivum* were grown in F_1 and F_2 rows this year. Some of these were backcrossed to the common-wheat parent, and a new series of simple crosses was effected as well. The incomplete expression of the branching characteristic often results in the development of up to nine kernels per rachis-node instead of the usual three to five grains. Some of these interspecific crosses were made using dwarf wheats as one of the parents. It is hoped that the combination of increased grains per head from the branched-spike parent and the increased tillering from the dwarf parent will result in commercially acceptable wheats with high yielding ability.

Although winter types account for most of the wheat grown in the region, there is a need for good spring types. European spring wheat introductions have also proved to be well adapted here. More than 20 of the best varieties were selected for yield trial analysis and preliminary multiplication. In addition, the backcross program to form spring wheats using six French winter wheats as the recurrent parents is well advanced. This work received additional impetus during the year when arrangements were made with Dutch workers to grow segregating lines in the field in Holland during the Chilean winter season. Over 700 F_3 and F_4 selections from September-planted material were sown at Wageningen, Holland, during March. This material will be screened and returned to Chile in time to be replanted in August.

The development of durum wheats with winter growth habit is in progress, and it is expected that incorporation of this factor will help extend the range of cultivation of this class of wheat. Approximately 100 crosses between durum wheats and common wheats of winter growth habit were grown as F_1 rows this year. In addition, backcrosses were made with the durum parent and 81 new combinations. Resistance to stripe rust and short, stiff straw—factors largely absent in durum wheats—as well as the winter growth habit, are being emphasized in this work.

Varieties and selections seeded at the Southern Experiment Station during the year totaled 13,319 entries.

CULTURAL PRACTICES

Inadequate cultural practices in this region are more often responsible for low yields than are weather hazards, unsuitable varieties, or pests. Provided they are managed properly, the commonly grown varieties produce high returns.

Low soil fertility is the most important factor limiting wheat production in this region. Experiments show that nitrogen and phosphorus are the principal elements limiting yields; in trials at Temuco, no measurable response to potassium was observed. To provide urgently needed response surface data, a series of rotatable design experiments is being conducted in cooperation with specialists from the Soils Section of the Department of Agricultural Research.

The best responses of winter wheats to nitrogen fertilization with adequate phosphorus were obtained with applications of one-third to one-half the total nitrogen at the

Band application of phosphate fertilizer in the rowing-out operation of the wheat nursery.

time of seeding, as compared with application of all the nitrogen either at the time of seeding or at the tillering stage. In contrast, the best response of spring wheats with adequate phosphorus was obtained by applying all the nitrogen at the time of seeding. The common practice in the region is to apply all the nitrogen at tillering.

The breeding nursery is grown under high soil fertility, which is achieved by the application of 96 kg./ha. of nitrogen as sodium nitrate and 200 kg./ha. of phosphate as triple superphosphate. The nitrogen is applied in three equal broadcast operations, and the phosphorus in the row at the time of seeding. Thus, the wheats selected for further development and evaluation tend to be those which respond well to fertilizer applications. To determine whether this practice might eliminate wheats that would do well under low fertility, four different winter wheat varieties were grown under four fertility levels of nitrogen and phosphorus. It was found that the relative yield positions of the varieties were essentially similar throughout the fertility range, although at the high level there was a greater difference between the more productive and less productive varieties. No significant variety-fertilizer interaction was observed.

The best rate of seeding of the varieties Cappelle and Vilmorin 29 was again found to be 120 kg./ha. when drilled in mid-May. This contrasts sharply with rates of seeding used by farmers in the region which range from 180 kg./ha. to 250 kg./ha. The common belief of these farmers that one can "compensate" for underfertilization by overseeding may account for the general tendency to plant at excessive rates, since bird damage at emergence is generally not serious. A comparison of two seeding rates, 120 kg./ha. and 250 kg./ha. at three fertility levels, showed the lower rate to be the best in all cases.

In a date-of-seeding experiment, it was found for the second year that the best yields of winter wheats were obtained from mid-May plantings. A higher incidence of "take-all" (*Ophiobolus graminis*) was also observed in the early-seeded plots and affected yields. The best yields of spring wheats were obtained from a late July seeding, in contrast to a mid-August seeding the previous year.

SOUTH-CENTRAL EXPERIMENT STATION

Wheat investigations located at the South-Central Experiment Station, Chillán, serve the region between the provinces of Talca and Malleco. The average rainfall in the region ranges from about 25 inches to 45 inches per year, the peak rain period occurring during the winter months. Wheat is grown both under dryland conditions and with supplemental irrigation, irrigated wheat being confined largely to the central valley. In this region where more than 200,000 tons of wheat are produced annually, average yields are among the lowest in Chile. The wheat is often planted on severely eroded land and cultural methods are inadequate. Much of the wheat is cut by hand, and threshing with animals and hand winnowing are still common sights at harvest time.

VARIETAL IMPROVEMENT

Both winter wheats of the south and spring wheats of the north are grown in this intermediate wheat zone, but these do not yield their best in this area. On the basis of accumulating data from yield trials conducted at the experiment station, a different set of varieties is emerging for the region which includes both winter and spring types. Preliminary results show that some spring wheats can compete with winter wheats from both fall and spring seedings.

Among the best winter wheat introductions chosen for further increase are Pax Cambier, Alter de Gembloux, Heurtebise, and 1940 Druchamp. Artois Desprez has yielded well in experimental plots but susceptibility to shattering disqualifies it from consideration as a commercial variety. Also chosen for preliminary multiplication on the basis of yield, agronomic type, and quality is the variety Magdalena.

Among the spring wheats tested, promising prospects for this region are semi-dwarf lines from the Mexican cross Yaktana 54 × Norin 10-Brevor. Four selections from this cross have been chosen for preliminary multiplication. The best of these lines has yielded from spring seedings roughly 30% more than Cappelle planted in the fall. A selection from the cross Gabo × Newthatch/Mentana-Kenya/Mentana has also performed well during the last two years.

The approach used in the hybridization work at this station has been to concentrate on crosses between spring and winter wheats to combine the best features of each parent. The F_2 populations from these crosses are then seeded at all three regional stations. Samples from some of these crosses have also been planted in Mexico and Uruguay. During the year more than 600 spring wheat × winter wheat crosses were made; these included combinations of the branched-spike *T. turgidum* and common wheats of spring growth habit.

A total of 9,994 entries was studied at the Chillán station during the year.

CENTRAL EXPERIMENT STATION

Investigations located at the Central Experiment Station, Santiago, serve the wheat area north of Linares province, where the average rainfall ranges from 2 inches to 30 inches per year. Dryland wheat is grown mostly in the coastal mountain range, and irrigated wheat mostly in the central and transverse valleys. Excellent yields can be obtained with both. The annual wheat production of the region exceeds 360,000 tons, of which about 80,000 tons is durum wheat.

VARIETAL IMPROVEMENT

Spring wheats from Mexico and Colombia have proved to be generally well adapted in this region and, in fact, the new varieties being released, and many superior wheats now in yield trials, were selected from among wheats developed in those two countries. Consequently, evaluation in Mexico and Colombia of new F_2 populations and new fixed lines selected for yield trials has become a standard feature of the region's wheat improvement program. In addition, well-adapted, rust-resistant wheats were selected this year from among F_3 and F_4 lines received from Mexico. These wheats had been previously sent to Mexico as F_2 and F_3 populations for screening for rust resistance and adaptation.

Plants of good agronomic type and rust resistance were also selected from 285 Peruvian crosses grown as F_2 in Chile this year. Many of the plants, however, were unacceptable owing to the excessive brown necrosis they exhibited under Chilean conditions.

Other wheats of good agronomic type were found among the Australian and Italian introductions. In contrast to the Mexican and Colombian selections, these wheats do not have adequate resistance. The Italian wheats, for example, are universally susceptible to the stem-rust races prevalent in Chile. Extensive hybridization and selection are being conducted to transfer factors for resistance to these wheats, and stem-rust-resistant lines of the high-yielding Italian varieties Mara, Generoso, Campodor, and Funo have now been developed.

The Australian wheats, on the other hand, are generally susceptible to stripe rust. Crosses were therefore made this year between a number of new Australian wheats and resistant spring wheats of Western Hemisphere and European origin. These latter may possibly have resistance factors for stripe rust other than those currently existing in the Western Hemisphere spring wheats. Whether the stem-rust resistance of the Australian wheats will be effective in Chile is not yet clear.

Dwarf and semi-dwarf spring wheats continue to receive emphasis because of their resistance to lodging, excellent tillering capacity, and high yielding ability. Selections from the cross Yaktana 54 × Norin 10-Brevor and other crosses involving the Norin 10 dwarf factors were again among the highest yielding wheats in the comparative trials. Stem-rust- and stripe-rust-resistant lines have been screened from the dwarf wheat nursery and a number of these were selected for preliminary multiplication.

Leaf-rust-resistant, dwarf forms of Orofén are nearly ready for yield trial studies. Lines homozygous for height, rust resistance, and general conformity to the Orofén type were planted in the summer nursery. The last series of backcrosses of this project was grown as F_1 in the summer nursery.

Selected composite or multilineal varieties of Lerma 52 and Frocor were again grown this year. Improved soil-water relationships in the nursery led in general to much better yields. In contrast, however, to previously reported results, none of the composite yields was superior to that of the highest yielding line entering into the multilineal variety. In fact, the trend was for the composite varieties to yield less than the combined average of the lines entering the variety.

A total of 28,212 fall-sown spring wheats and 3,638 winter wheats was studied during the year, and an additional 9,149 spring wheats were grown during the summer. Thus, with two generations of breeding material per calendar year, the approach to homozygosity can be more rapid.

DURUM WHEAT

Durum wheat production in Chile is currently threatened by the existence of virulent races of stem rust and by competition from high-yielding, early-maturing common wheats. Even though a higher price is paid for durum wheat, many farmers now prefer to grow bread varieties. Durum improvement is therefore being given greater emphasis.

A 1-hectare increase plot of a durum wheat derived from the Colombian cross Arabian × Sernai Caieh was planted in the summer nursery. This variety is resistant to stem rust and matures earlier and has better straw than the widely grown Cappelli types. Although the variety yields well, it was severely attacked by powdery mildew (*Erysiphe graminis*) in a most unusual epidemic which occurred this year, and as a result the grain produced was of substandard quality for use in the preparation of semolina products. Testing will be continued to determine further the effect of mildew on this wheat.

Inspecting wheat seedlings infected with rust.

Should this variety prove inadequate, stem-rust-resistant Capelli types of proved acceptability are now in preliminary increase. As the Capelli type, however, is not able to compete in yield with the common wheats, it and other types have been crossed with dwarf durums from Mexico and North Dakota.

The new North Dakota durum varieties Wills and Lakota were judged inadequate for Chilean conditions on the basis of yield and grain characteristics, even though resistant to stem rust.

A total of 3,726 durum entries was studied during the year.

FARINOLOGY

Wheat quality investigations by the Office of Special Studies began in 1958 with the opening of the farinology laboratory in Santiago, and since then, additional equipment has been installed to provide more modern and complete testing facilities. The output of the laboratory has steadily increased each year, as measured by the numbers of samples analyzed and the kinds of tests performed, until now the capacity of the laboratory to analyze parental wheats, experimental varieties from yield trials, and varieties in agronomic trials matches the production of this material at the three regional stations. It has therefore been decided to begin testing seed from individual F_2 plants harvested this season for early generation selection of the families with better quality characteristics.

Among the routine data taken on whole or ground grain are test weight, Pelshenke time, hardness index, and milling quality. Flour from the experimental mills is used for rheological and baking tests. During the year more than 1,700 wheat samples were analyzed, and duplicate baking tests were conducted on over 1,600 of these.

Thus far, the largest proportion of wheats analyzed has been of the spring type grown at the Central Experiment Station. These tests have proved that excellent quality for bread and high yield can be combined in wheats agronomically suited for the northern wheat region. The best selections in this respect are from the following crosses: Gabo × McMurrachy-South Africa 43; Kenya 340 × Frontana-Thatcher; and Frocor × McMurrachy/Kentana-Yaqui.

Although all of the high-yielding winter wheats so far tested from the south have inferior bread-making qualities, minor differences in quality do exist. Druchamp and Marne, which are well-adapted varieties, have produced the best bread among this group. Some wheats from outside this group, especially a number of Argentine and North American varieties, maintain good quality characteristics when grown in the south of Chile. Quality improvement for this region is progressing through the development of soft-textured wheats derived from crosses made with these wheats of good quality.

OATS

Oats are used primarily for grazing, soiling, or silage in Chile and provide excellent winter forage for livestock. Interest in the crop is thus derived primarily from its value as a source of fodder, even though over 100,000 tons of grain are fed annually. With more than 100,000 hectares sown to oats each year, they are second only to wheat in terms of acreage grown.

In view of limited information available about varietal performance and the management of oats in Chile, investigations have been initiated to provide improved seed and a basis for recommendations concerning agronomic practices. This research is being conducted at all three regional stations but is being emphasized at the Southern Experiment Station since about 80% of the national acreage is grown in the area served by this center.

In progress is a series of experiments designed to evaluate varietal performance and the effect of date of seeding, rate of seeding, and clipping frequency, as well as the interaction of these factors on grain and forage yields. In cooperation with soil specialists from the Department of Agricultural Research, experiments to measure fertilizer responses have also been started.

A world oats collection of more than 3,500 entries, furnished by the U. S. Department of Agriculture, has been screened for desirable characteristics. From these and other introductions, over 200 oats of good type were selected for comparative trials with the locally grown varieties. Several of the selections are being increased while additional data on their performance are accumulated. Pure lines of the local varieties are being obtained through the increase of individual plant selections from this material.

Parasitic diseases which have been observed in the nurseries in Chile are stem rust (*Puccinia graminis* var. *avenae*), crown rust (*P. coronata*), covered smut (*Ustilago hordei*), and halo blight (*Pseudomonas coronofaciens*). A red leaf condition, similar to that caused by the barley yellow-dwarf virus, has also been observed. The race 6A-13A complex of stem rust, reported in Colombia, and the Landhafer races of crown rust have not been noted.

Harvesting a red clover clipping trial at the Central Experiment Station, Santiago.

Forage

Two new legumes released by the Office of Special Studies last year—the red clover variety Quiñekeli and the alfalfa variety Ligüen—have performed well in seed increase fields. About 4,000 kilograms of registered seed of Quiñekeli were harvested this season, and plans are being made with the seed production and seed certification units of the Ministry of Agriculture for the planting of 1,500 hectares for certification this year. This should provide enough certified seed for 40,000 hectares by next year.

The 1,500 kilograms of registered seed of Ligüen harvested at the Central Experiment Station will be distributed to certified seed producers. About 500 hectares can be established this year, and this should produce enough seed to sow 15,000 hectares in 1963.

In December, 1961, the First National Forage Congress was organized at Chillán by the Ministry of Agriculture, the University of Concepción, and local farmer organizations. The forage research personnel of the Office of Special Studies contributed to these meetings, both in the organization and in the presentation of research results. This group is also participating in meetings organized by the extension and seed production units of the Ministry. Though time consuming, these extra-research activities provide a good opportunity to reach the farmers with recommendations and to hear directly from them about the problems they encounter in forage and pasture production.

Recently, with the appointment of Dr. Melvin G. Greeley, the basic organization of the forage program has been completed. The work has been divided into three sections: forage improvement, pasture and range management, and forage and pasture utilization.

Dr. Donald L. McCune left Chile in early 1962, after almost four years of valuable contributions to the forage program.

Dr. Royse P. Murphy, Head of the Department of Plant Breeding at Cornell University, is in Chile on sabbatical leave as a temporary staff member of the Foundation. He is consulting on forage improvement problems and assisting in the training of personnel and students.

The forage program is receiving valuable cooperation from the National Agricultural Society through its experiment station at Paine, and from the Development Corporation which is making land available for dryland studies at Concón.

LEGUME AND GRASS IMPROVEMENT

As previously reported, breeding work is largely concentrated on two major legumes and two grasses: alfalfa (*Medicago sativa*), red clover (*Trifolium pratense*), orchardgrass (*Dactylis glomerata*), and perennial ryegrass (*Lolium perenne*).

ALFALFA

Nematodes, particularly stem nematodes, present the most serious problem for the successful production of alfalfa under irrigation in the central zone and in some valleys of northern Chile. In a four-year-old trial on soil heavily infested with both rootknot and stem nematodes, a local selection from the Huasco Valley is now superior in stand and yield to all others except Lahontan, the winter-dormant, stem-nematode-resistant check variety. Twenty plants with a high degree of resistance to the stem nematode have been selected from this local selection and are currently being increased and their progeny tested. Since this selection is well adapted and has sufficient winter growth to be useful, an early release of a stem-nematode-resistant variety may be possible.

Rootknot nematode galls in alfalfa.

A series of crosses has been made to combine the excellent winter growth and productivity of Ligüen and the stem-nematode resistance of Lahontan. Resistance to the rootknot nematode is also being added to Ligüen from some resistant selections from California.

The project to combine the creeping-rooted habit of growth with winter production, which was reported last year, has been continued. Rigorous selection for both characteristics has produced 25 promising clones for progeny testing and recurrent selection.

From a four-year-old trial growing in soil heavily infested with both rootknot and stem nematodes, 55 plants were selected in the variety Moapa and intercrossed in a screened cage with bees as pollinators. The progenies will be tested in the greenhouse to determine their resistance to both nematodes.

From another four-year-old trial, at Osorno, in which many plants were defoliated by diseases, largely *Pseudopeziza medicaginis*, several plants showing autumn vigor and excellent disease resistance were selected, and polycross progenies will be further evaluated under field conditions in the central zone and the coastal drylands.

Several plants outstanding for vigor under extremely dry conditions and with moderate resistance to foliar diseases have been selected from a three-year-old variety trial in the coastal drylands. They have been intercrossed and their progenies will be evaluated in the same area. Two other polycrosses were made using selections from dryland areas.

Outstanding drought tolerance and recovery after seed harvest have been observed in a local collection of alfalfa from the Andes Mountains near Santiago. Open-pollinated seed from selected clones has been harvested and will be evaluated under coastal dryland conditions.

To aid the breeding program in Chile, and in other countries, the Chilean collection of alfalfas, begun in 1957 by Mr. C. O. Grandfield, was increased this year by approximately 80 samples selected from the major valleys and high slopes of northern Chile. Many of these latter samples have a long history of isolation.

RED CLOVER

Quiñekeli, together with two other local strains and the imported varieties Pennscott, Reinholdt, and Chesapeake, continues to be the most productive. These six varieties were crossed by hand in all possible combinations and the F_1 plants grown in space-planted rows at the Temuco station. The F_2 seed will be sown at both Temuco and Santiago, and at the latter the progenies will be evaluated in soil heavily infested with crown- and stem-rotting organisms.

Evaluation for disease resistance, winter vigor, and recovery after cutting has been continued at Temuco in the nursery of several thousand plants representing 18 origins. Approximately 25% of the plants have been eliminated as undesirable.

The late maturity of Quiñekeli, characteristic of most of the local strains, may present a problem in seed production in some areas. Work has been initiated to improve the variety in this respect. From a space-planted nursery of more than 3,000 plants, approximately 100 plants, one to two weeks earlier in flowering, were selected and allowed to intercross naturally; all others were cut to prevent outcrossing with undesirable types. Bulked seed from the selected plants will be compared with certified Quiñekeli at each selection stage to determine whether the new selection is equal to Quiñekeli in other varietal characteristics.

Methyl-bromide treatment for nematode control in red clover plots at Osorno resulted in good establishment and growth (untreated plot in foreground).

Trials to study the effect of nematodes, soil insects, and foliar insects have been initiated at Santiago, Temuco, and Osorno. In first-year observations at Osorno nematode control appears good in the methyl bromide plots. In contrast, at Temuco, only a slight improvement is apparent with the same treatment. The heptachlor treatment for control of soil insects showed no appreciable improvement over the untreated check plots at either location. The four test varieties, Quiñekeli, Pennscott, Chesapeake, and Sanford, were essentially equal in the methyl-bromide plots, but with all other treatments Quiñekeli was considerably better than the imported varieties.

ORCHARDGRASS

Although in total production no significant differences have been observed among the leading varieties of orchardgrass in Chile, within the different collections of clones there is considerable variation in late fall and early spring growth, disease resistance, and plant type. The possibility of changing the seasonal distribution of production and the quality of the foliage appears promising.

At Santiago three groups of clones of different maturity classes, selected at Osorno and Chillán on the basis of their winter vigor and rust resistance, were grown in isolated polycross nurseries. Clonal progenies will be evaluated at Chillán, Osorno, and Santiago.

At Osorno 72 clonal lines, selected from a large clonal nursery of local material, have been evaluated for winter vigor and rust resistance. The best 10 lines will be further evaluated in replicated plots in 1962. Selected clonal lines from the Mediterranean Collection (FAO) were selfed under plastic cages. Several crosses are scheduled with this material in 1962. The selfed lines will also be evaluated at Chillán and Santiago.

More than 80 lines from the United States and Canada are being evaluated at Chillán. Additional selections for rust resistance are being made in the Chilean, USDA, Mediterranean (FAO), and California collections.

At two locations in the coastal drylands three selections of orchardgrass growing in space-planted rows show considerable vigor and drought tolerance. These were selected from an old clonal nursery on an extremely dry site on the experimental farm of the University of Chile.

PERENNIAL RYEGRASS

Preliminary information indicates that more productive and better-quality perennial ryegrass varieties can be produced by selecting for rust resistance and vigor simultaneously in material presently available. At the Central Experiment Station 57 lines from the FAO collection and from selected varieties have been evaluated for these characteristics. Resistance to the local collection of crown rust and stem rust exists in some lines, and some of the resistant clones also show excellent vigor. Crosses will be made between selected clones within and between lines.

Thirteen lines from the FAO collection were also grown in transplanted rows at two locations in the coastal drylands. All lines showed good spring and early summer growth but became dormant and brown in late summer.

A clonal nursery of ryegrass for selection for rust resistance at Santiago. Plants in flats are being inoculated with crown rust.

VARIETY TRIALS

Extensive performance trials have been conducted for a period of four years at the Santiago, Chillán, Temuco, Valdivia, and Osorno experiment stations and on private farms in several parts of Chile. On the basis of the results from the trials, recommendations for the different agricultural zones are being made for most of the major species.

ALFALFA

In the central zone the most nonhardy varieties continue to show the highest level of productivity. They provide an additional cutting during the winter months, when feed supply is critical. While these varieties may be severely attacked by some leaf and stem diseases in the more humid and cooler areas of the coast and the south, they showed moderate resistance to a severe attack by rust (*Uromyces striatus*) at Santiago during the past season.

Trials at Chillán indicate that varieties with slightly more winter dormancy than Ligüen give a higher total production; in addition, many of them show considerably more resistance to leaf and stem diseases. The leading varieties for 1960–1961 and 1961–1962 were Peruana, Caliverde, Franconia, California Common, Arizona Chilean 21–5, and Du Puits.

RED CLOVER

Varietal differences in regional adaptation are beginning to be manifested in the several trials conducted at Santiago and Temuco. At Santiago, Quiñekeli and other local strains showed moderate resistance or tolerance to the root- and crown-rotting organisms so destructive to most of the imported varieties (Table 1). In addition, a severe rust epidemic damaged many of the imported varieties, particularly Pennscott and Reinholdt. At Temuco, in a trial established in 1959, the imported varieties Reinholdt, Pennscott, Kenland, and Chesapeake have maintained a better stand and produced a higher yield in 1961–1962 than the best local strains. In a new trial established in 1961, however, Quiñekeli is showing slightly more vigor and production than other local and imported varieties. The reason for the variable performance of the varieties in the Temuco trials is not yet clear.

TABLE 1.

Green weight yields of red clover varieties. Santiago, 1961–1962.

Variety	YIELD Ton/ha.[a]	 % Quiñekeli
Local Selection A	125.5	100
Quiñekeli	125.1	100
Local Selection B	118.9	95
Local Selection C	118.8	95
Kenland	115.7	92
Chesapeake	110.5	88
Kentucky-215	102.1	82
Sanford	94.2	75

[a] All varieties gave five cuttings.

OTHER LEGUMES

There has been no major change in the performance of varieties of white clover, the Ladino varieties having maintained their yield superiority over other types of white clover at all locations. In the Osorno trials the stands have been reduced after a severe summer drought, but the relative advantage of the best Ladino over the New Zealand variety has been as great as in the previous two years. At Chillán the productive advantage, 120% of New Zealand, has been even more pronounced.

Kimey, the newly released variety of birdsfoot trefoil, has continued to perform well. Other varieties of *Lotus corniculatus* from Argentina and the United States have also shown promise, particularly in the Chillán area.

GRASSES

Orchardgrass is the most important forage grass in Chile, occupying approximately 250,000 hectares in nonirrigated areas and 2,000 hectares under irrigation. Most of this area is seeded with locally produced seed. The Chilean variety Centifén and an introduction, New Zealand (M.A.), are recommended for certification. In trials to date no single variety has been consistently outstanding.

Since no ryegrass varieties have yet been developed in Chile, all local seed stocks are derived from the increase of rather recent importations or from local annual types. The two varieties recommended are both from Australia: Short Rotation, for irrigated and humid areas, and Wimmera (*L. rigidum* × *L. multiflorum*), for dryland.

Fescue is rather widely used in the South, but Kentucky-31 is currently the only variety eligible for certification. Data from Osorno indicate a marked superiority of *Festuca arundinacea* selections over those of *F. elatior.*

No improved varieties of hardinggrass have been developed in Chile, but the species, *Phalaris tuberosa* var. *stenoptera*, is grown for certification. This grass is important for pasture mixtures in the nonirrigated areas and in the coastal drylands, primarily because of its excellent winter growth and drought tolerance. In trials at several locations the imported varieties Wilson and Victoria and several local seed lots of hardinggrass have performed well.

MANAGEMENT

SANTIAGO

Establishment studies of alfalfa with wheat as a companion crop have indicated that the production of wheat is not affected by reducing the wheat seeding rate or by spacing the rows at double the normal distance. In the second year, however, the production of alfalfa seeded alone has been more than 300% that of the alfalfa established with wheat as a cover crop (Table 2).

TABLE 2.

Green weight yields of alfalfa following establishment with and without a companion crop of wheat. Santiago, 1961–1962.

Method of establishment in 1960	Yield 1961–1962 (ton/ha.)
Alfalfa seeded alone	30.97
Alfalfa seeded with 60 kg./ha. of wheat	11.27[a]
Alfalfa seeded with 120 kg./ha. of wheat	9.36

[a] Best of 15 treatments with different rates of seeding, row spacing, and wheat varieties.

With red clover, results in favor of seeding without a companion crop were not as striking, but still favored seeding of the legume alone.

Total production of oats for soiling was increased when seeded with red clover, and the establishment of the legume was acceptable. However, the yield of red clover the following season was considerably lower than when it was seeded alone: 33.78 ton/ha. (green weight) as compared with 53.34 ton/ha.

Three white clover varieties subjected to cutting frequencies ranging from 3 to 28 days responded similarly, all giving best yields with the 28-day cutting interval. These results are in close agreement with those obtained at Chillán.

In trials with alfalfa and red clover, best yields were obtained with cutting at 25% bloom.

CHILLAN

A mixture of Ladino, alfalfa, orchardgrass, and fescue, planted four years ago for a fertilizer study, is now completely dominated by Ladino and some orchardgrass. Responses to increasing rates of phosphorus applied during establishment are still noticeable, and the plots that received a second application show even greater differences. It is clear that shallow-rooted legume pastures benefit from yearly applications of phosphorus in the trumao soils of Chile (Table 3).

TABLE 3.

Green weight yields (ton/ha.) obtained in a four-year period from a Ladino-alfalfa-orchardgrass-tall fescue mixture planted in 1958. Chillán, 1958–1962.

	YIELD	
P_2O_5 unit/ha. per application	With 1 application (1958)	With 2 applications (1958, 1959)
0	178.6	172.3
75	194.9	229.5
150	212.6	265.3
300	252.0	292.7

It is interesting to note that in both alfalfa and red clover fertilizer trials on trumao soils of this region, the addition of lime to superphosphate has a small depressing effect. In these soils maximum production is apparently not being obtained even with 300 units of phosphate per hectare. The economics of using these higher quantities of fertilizer is being studied further.

As at Santiago, better establishment of a pasture is obtained when the companion crop is cut for soiling than when it is left to mature for grain. These results are significant, considering that traditionally farmers establish pasture with a cereal companion crop, generally wheat, for grain production.

TEMUCO

The area of Chile south of Temuco has recently experienced its most severe drought in more than 25 years. The unusually long dry period lasted from December, 1961, to April, 1962, so that conditions during the past growing season have been abnormal.

A series of experiments on method and date of seeding has been concluded. Good results were obtained with bandseeding, and it was found that the amount of fertilizer needed for satisfactory establishment can be reduced considerably. Because of frost damage to small-seeded forages planted from May to August, the use of a companion crop is generally recommended, except for early fall and spring seeding, in the region from Temuco south.

With alfalfa, weed competition during establishment is a major problem that has yet to be solved, but with proper fertilization and weed control, establishment and production have been extremely high, considering the prevailing drought. It is interesting to note that in the second growing season yields have been similar for all the fertility treatments imposed the previous year for establishment, and the unfertilized check plots have improved in growth and production in the second year (Table 4). These responses may be due to the deep-rooting habit of this legume, and to the high phosphorus-fixing capacity of the soil.

As at Chillán, experiments are in progress to overcome the unthrifty condition shown by orchardgrass. Here, the addition of 20 ton/ha. of barnyard manure to the treatment with mineral nitrogen, phosphate, and potash, boosted production another 50% (from 12.38 ton/ha. green weight to 18.25 ton/ha.).

TABLE 4.

Green weight yields of alfalfa (ton/ha.) during the second season as affected by fertilization at establishment. Temuco, 1960–1962.

P_2O_5 applied in 1960 (kg./ha.)[a]	Av. yield per cutting 1960–61	1961–62
Check	8.5	17.1
80 bandseeded	20.2	21.8
350 broadcast	21.7	23.1
80 bandseeded + 350 broadcast	30.7	23.7

[a]Selected from a trial with 32 entries.

OSORNO

In the establishment studies with alfalfa there has been a marked response to lime in the second year, as well as the normal response to phosphorus expected on the trumao soils. This is interesting since practically no response to lime was observed during the first year (Table 5).

TABLE 5.

Green weight yields of alfalfa (ton/ha.) as affected by liming. Osorno, 1960–1962.

	YIELD	
$CaCO_3$ applied (kg./ha.)[a]	1960–61	1961–62
Check	15.20	26.90
1,600	18.25	36.33
6,400	17.80	41.37
25,600	20.15	53.55

[a]All treatments received 450 kg./ha. of P_2O_5, 100 kg./ha. K_2O, and 32 kg./ha. N.

In the coastal region of Osorno, where subterranean clover varieties have been producing two cuttings per season, Tallarook has been among the best. This past season, however, only one cut was obtained in late October, and Tallarook was outyielded by

Intercrossing clones of creeping-rooted alfalfa in the greenhouse, Santiago.

Bena, Romsey, and Nangela. After this one cut, all the varieties recovered only enough to reseed.

In this same region, an effect from minor elements was apparent for the first time. A mixture of orchardgrass, ryegrass, birdsfoot trefoil, and red clover planted in 1960 is now completely dominated by red clover, but the plots that received minor elements contain up to 20% of orchardgrass. Total production in plots receiving minor elements showed no increase.

VALDIVIA

On the basis of data from several fertility trials established in 1959, 1960, and 1961, the following conclusions have been reached: (a) the use of phosphate is required to establish a legume grass-mixture; (b) potash does not increase production during the first season, but its effect becomes apparent in the following seasons in the increased longevity of red clover; (c) addition of barnyard manure always raises production over the complete formula with mineral nitrogen, phosphate, and potash; and (d) bandseeding is the best method tried to date for establishing small-seeded forages.

In the flat and poorly drained lands, good stands of birdsfoot trefoil, subterranean clover, alsike clover, perennial ryegrass, orchardgrass, and tall fescue have been obtained. Fertilization is even more important in these soils, where none of these species can be established without the use of phosphate.

DRYLAND

Studies have been continued at six locations in the central zone, an area with an average of six months during the summer without any rainfall.

The alfalfa trials established at two locations in Santo Domingo have completed their second and third productive seasons. Results show the adaptation of this species to the deep, light-textured soils near the sea. Again this season the varieties most commonly used, Peruana and Caliverde, were among the best yielders. The nonhardy varieties, with better seedling vigor and recovery, have not outyielded other types. The trials at Concón continue to show the poor performance of alfalfa on the granitic and heavily eroded soils that are so abundant in the coastal ranges.

Marrar, a new addition to the variety trials of subterranean clover, is showing excellent adaptation. It yielded as well as Bacchus Marsh, Wogenelup, and Yarloop at Concón, and reseeds readily because of its earliness. In the Santo Domingo area, where alfalfa is adapted, and in the interior dryland, where drought is more intense, subterranean clover does not reseed well. At Paine, near Santiago, the annual medicagos are showing better adaptation than subterranean clover.

Studies with vetches and other winter annuals have been continued. The vetches, with or without oats, are producing excellent yields of green material that can be ensiled and used as a supplement during the critical period in autumn and early winter.

Where alfalfa is adapted, as at Santo Domingo, alfalfa alone still yields as well as or better than any mixture with a grass after three years of testing. Wider spacing of the alfalfa rows has not shown any advantage under these conditions.

Again this year the application of 100 units of nitrogen per hectare in oats did not increase production as much as seeding an annual legume with them.

A fertilizer study with subterranean clover at Concón, now in its second season, again showed a sharp increase in production with the treatments containing phosphorus. Establishment of this crop is practically impossible in the granitic dryland soils without phosphorus fertilization.

UTILIZATION

The grazing trial conducted at Chillán in cooperation with the Animal Science Department of the University of Concepción is in its fourth season. In the third season, as reported previously, over 1,250 kilograms of beef per hectare were produced, under both the continuous and the rotation grazing treatments. Since September, 1961, when the present grazing season was started, beef production per hectare has exceeded 1,450 kilograms in both treatments, in spite of an outbreak of hoof-and-mouth disease that occurred in January.

During the last two seasons a small but consistent increase in production has been obtained with rotation grazing. The productivity of the pasture has increased under both treatments as a result of careful management, which includes fertilization with phosphate every year. This experiment is demonstrating the high potential productivity of improved irrigated pasture in the central zone of Chile (Table 6).

As winter is the low period for pasture production under irrigation and in the rainy regions, winter-growing forage species are being evaluated for winter grazing, soiling, and silage. Among the cereals, oats is an excellent species for these purposes. It has been found that seeding it with a legume, such as vetch or berseem clover, gives a high yield of nutritious forage.

At Santiago, sorghums and sudangrass have produced excellent yields of green material for ensiling. The best sudangrass variety produced a green weight yield of 112.6 ton/ha., with approximately 20% dry matter. The best single-harvest sorghum variety yielded 111.5 ton/ha., with approximately 25% dry matter.

TABLE 6.

Kilograms of live weight of beef produced per hectare on a Ladino clover-ryegrass mixture at Chillán, 1960–1962.

Grazing system	3rd season (Sept. 22, 1960–May 9, 1961)	4th season (Sept. 5, 1961–May 1, 1962)[a]
Continuous	1,272.5	1,458.0
Rotation	1,325.0	1,566.0

[a]Season in progress.

Exterior cyclone fence, Santiago.

Experiment Station Development

The experiment station development program has as its immediate objective the design and construction of two principal stations with integrated irrigation and road systems, as well as a functional and coordinated physical plant. To this end, construction of research facilities is proceeding at the two new stations located near Santiago and Temuco. During the next few years, emphasis will continue to be placed on building construction, station maintenance, and further development of the field irrigation and drainage systems, as well as on the training aspects relating to applied agricultural engineering research.

Central Experiment Station, Santiago

The Central Experiment Station is located on the southern outskirts of Santiago and can be reached by auto or bus in a half hour from the center of the city. It is nearly square in shape and covers an area of 303 hectares of shallow alluvial soils representative of the zone. The topography is gently undulating and has a thin top soil (15–80 cm.) which is difficult to level. This station is divided into three sections by two communal irrigation canals which carry water to the adjacent farm lands.

CONSTRUCTION

The crop research buildings, including the headhouse and station cafeteria, are nearing completion. The farm shop, which has facilities for repair of farm machinery and vehicles, and for the fabrication of research equipment, has been operating since May, 1961. The station carpenter shop, located in the same building but isolated because of the dust problem usual to carpenter shops, was put in operation in October, 1961. Two workers' houses, among many other smaller items, have already been prefabricated in this shop.

Four greenhouses equipped with water, electrical power, and portable metallic benches are now in use by the crops research sections. Two of these are now equipped with hot water heating systems, but the boiler cannot be installed until the headhouse is completed. Evaporative coolers with thermostatic temperature and humidity controls were installed in three different sections of the greenhouses. These systems have been effective in reducing the excessive summer greenhouse temperatures.

A U-shaped warehouse, 1,500 square meters in area and with a raised loading ramp, was designed during the year. The foundations, floors, and 50% of the structure have been completed. The space will provide for a seed cleaning and treating plant, cold room, workers' cafeteria, lockers and showers, an office, and general storage.

One worker's house has been fabricated and a second is under construction. The house for the station administrator is nearing completion and foundations have been laid for the house of the field superintendent.

Detailed planning has continued on the buildings for the animal nutrition research center, previously designed by Mr. Norval Curry and Dr. James Fransen. The general problems of water, sewerage, and electrical power distribution are being studied with a view toward providing for future expansion. At present, however, detailed working plans are being completed for only three units—the metabolism laboratory, the beef nutrition unit, and the clinic. Funds are now available for these three units.

UTILITIES

The high tension line within the station was extended to the deep well which is to supply water for the future research buildings, farm shop, greenhouses, and warehouse. A 150 KVA transformer was installed to serve the farm shops, headhouse, and cafeteria and a third 50 KVA transformer was installed near the station warehouse for this building alone.

FIELD OPERATIONS

All the stone walls have now been removed from the fields and the stones have been accumulated at five different stockpiles on the station to reduce the hauling time spent in collecting them and in the distribution of the crushed rock over the present dirt road surfaces. The rock crusher and its power unit, which arrived in March, 1962, have been mounted on a reinforced steel wagon so that the complete unit can be moved from one rock site to another with a minimum of difficulty. The crushed rock will be used as roadbed material to provide an all-weather surface, and also in the construction of concrete-lined irrigation ditches.

Between October, 1961, and April, 1962, approximately 100 hectares of land were shaped and placed under border irrigation. This increases the area under borders to about 200 hectares, which was the projected objective. On another 30 hectares of very uneven land, a large crawler tractor and earth scraper were contracted to shape the land; this area, however, has not yet been placed under borders.

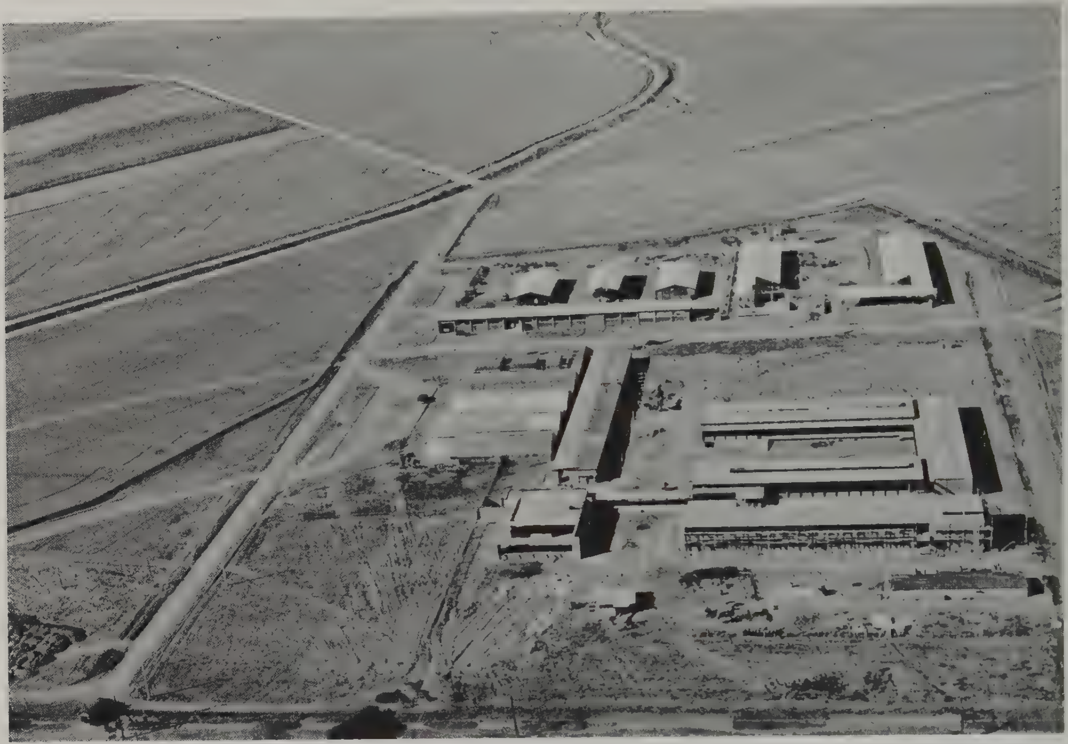
To date, approximately 1,100 meters of concrete-lined ditches and five concrete drops have been constructed on the east side of the station. This has helped considerably in reducing ditch maintenance and in providing better water control. In addition, a 9-meter reinforced concrete flume has now been installed in the above-mentioned line ditch to by-pass the irrigation district canal, which passes through the station.

A total of 6.5 kilometers of galvanized chain link fence mounted on reinforced concrete posts was completed on the two sides and rear of the station. Another 500 meters of fence on the front of the station will finish the enclosure of the station.

SOUTHERN EXPERIMENT STATION, TEMUCO

The Southern Experiment Station, which is located in the province of Cautín, 18 kilometers northeast of Temuco and about 700 kilometers south of Santiago, consists of 335 hectares of nearly level soils of volcanic origin. The soil, which is representative of only a portion of the zone, is somewhat deeper than at Santiago and hence more favorable for land leveling.

Construction at this station will be financed with Eo 948,000 (U.S. $632,000) in earthquake reconstruction funds loaned by the Government of the United States. These funds



Aerial view of the new crop research and administration units nearing completion at the Central Experiment Station, Santiago. *Front right*, administration and U-shaped laboratory buildings; *front left*, cafeteria; *center left*, headhouse and four greenhouse units; *rear right*, seed processing and storage units; *rear left*, repair shop and three machinery sheds. Plan on opposite page shows these units and projected animal research units.

have been approved for the crop research buildings and for some of the animal nutrition research buildings during the period 1962–1964.

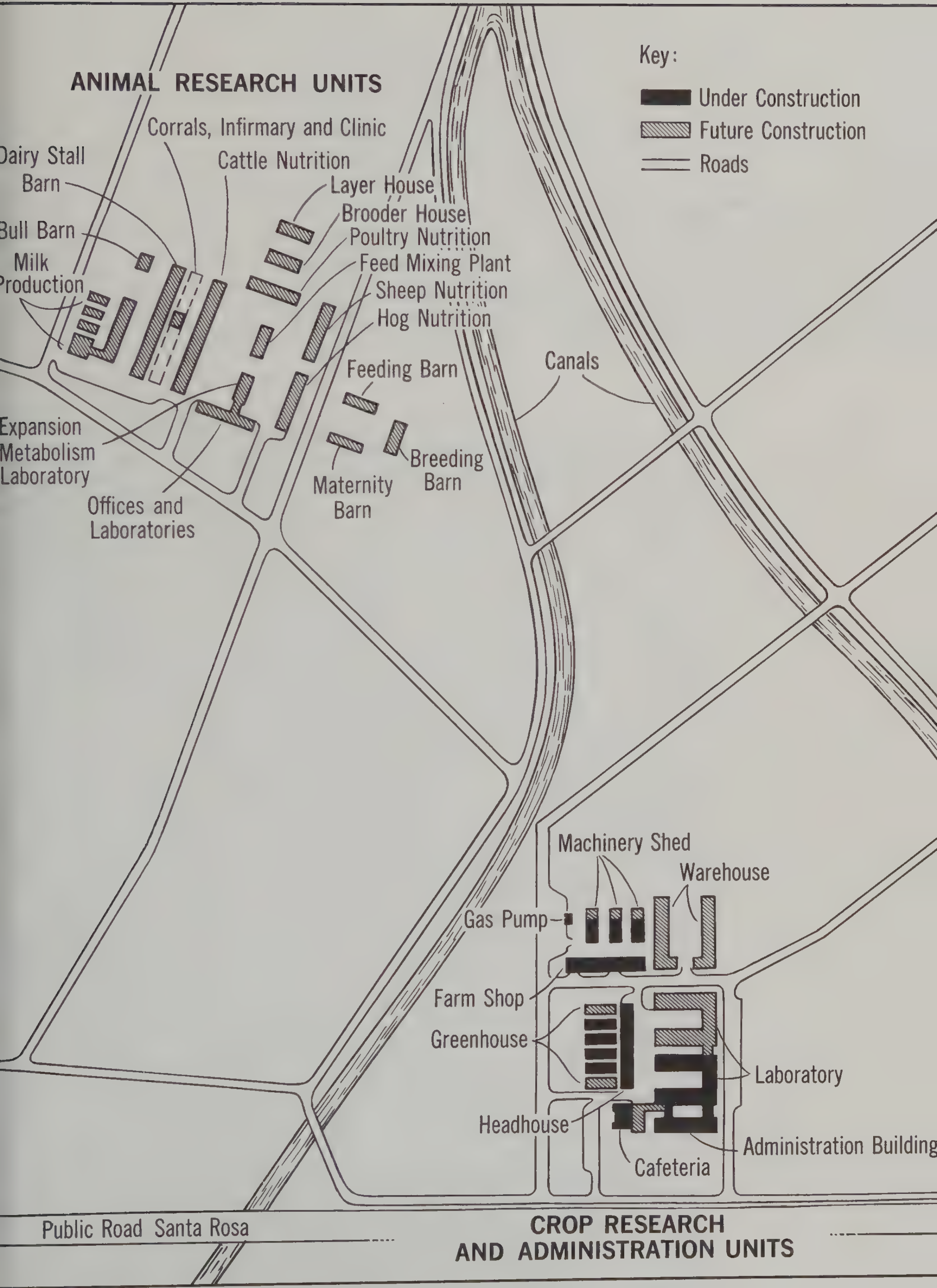
The Office of Special Studies has worked very closely with the local architects in developing complete architectural, detail, working, and utility plans for the research buildings. As soon as these are corrected and complemented, bids can be called by the Ministry of Public Works, which will supervise construction.

Detailed plans, including structural, electrical and working drawings, for the combined mechanical and carpenter shop have been finished and construction was initiated in November, 1961. Also nearing completion are detailed plans of the first three buildings of the animal nutrition center—the metabolism laboratory, the beef nutrition unit, and the clinic. Funds are available for these units.

The meteorology station was built during the year and some of the essential equipment installed. The resulting information from this meteorology station will be useful to the research sections in interpreting their results.

Two deep wells were contracted and finished during the year, one near the crop research buildings and the other within the proposed animal research area.

An additional 25 hectares of land have been readied for border irrigation to be used by the crop research sections, and several hectares were floated with a 40-foot land leveler.


ANIMAL RESEARCH UNITS
Corrals, Infirmary and Clinic
Cattle Nutrition
Dairy Stall Barn
Layer House
Brooder House
Bull Barn
Poultry Nutrition
Milk Production
Feed Mixing Plant
Sheep Nutrition
Hog Nutrition
Feeding Barn
Expansion
Metabolism Laboratory
Breeding Barn
Maternity Barn
Offices and Laboratories
Key:
Under Construction
Future Construction
Roads
Canals
Machinery Shed
Warehouse
Gas Pump
Farm Shop
Greenhouse
Laboratory
Headhouse
Administration Building
Cafeteria
Public Road Santa Rosa
CROP RESEARCH AND ADMINISTRATION UNITS

Indian Agricultural Program

Personnel

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Warren W. Sahs, M.S., Temporary Staff Member, Seed Production Specialist
Ray E. Armstrong, M.S., Temporary Staff Member, Experiment Station Operations
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Robert W. Hodgson, M.S., Temporary Staff Member, Visiting Professor, Post Graduate School (to April 12, 1962)

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Shri D. N. Sajnani, Technical Assistant
Shri R. D. Bansal, Technical Assistant
Shri V. L. Asnani, Technical Assistant (to October, 1961)
Dr. G. D. Pershad, Technical Assistant (to March, 1961)
Shri R. S. Punia, Technical Assistant (to October, 1961)
Shri D. S. Rana, Technical Assistant (to August, 1961)
Shri J. B. L. Mathur, Technical Assistant (to August, 1961)
Kumari Uma Aurora, Technical Assistant
Shri H. C. Sharma, Technical Assistant
Shri K. C. Katyal, Technical Assistant

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Shri Bhag Singh, Research Assistant
Shri T. R. Dayani, Research Assistant
Shri P. V. Rao, Research Assistant
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Shri M. B. Gurung, Research Assistant
Shri P. P. Thapa, Research Assistant

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Shri Bansi Lal Sah, Research Assistant

Arbhavi, Mysore

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Shri P. V. Hayavadan, Research Assistant

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Shri Ved Pal Gupta, Field Collector

Shri Man Mohan Sawhney, Field Collector
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Shri V. V. Thobbi, Entomologist, PIRRCOM Center (Surat)
Shri Jagdishwar Nath, Pathologist, PIRRCOM Center (Surat)
Shri A. S. Patel, Farm Manager, State Station (Junagadh)

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Shri Bhola Nath, Head, PIRRCOM Subcenter (Gwalior)

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Shri A. Subramaniam, Assistant Millet Specialist
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Shri R. C. Mandal, Agronomist, PIRRCOM Center (Coimbatore)

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Shri G. Vedamoorthy, Entomologist, PIRRCOM Center (Coimbatore)
Shri N. V. Sundaram, Pathologist, PIRRCOM Center (Coimbatore)
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Dr. V. M. Sahni, Head, PIRRCOM Center (Amravati)
Dr. M. R. Siddiqui, Pathologist, PIRRCOM Center (Amravati)
Dr. R. L. Tripathi, Entomologist, PIRRCOM Center (Amravati) (to February, 1962)
Shri V. N. Bodade, Agronomist, PIRRCOM Center (Amravati)
Dr. B. K. Dhar, Agricultural Chemist, PIRRCOM Center (Amravati) (to September, 1961)
Dr. R. V. Vidyabhushanam, Head, PIRRCOM Center (Mohol)

Mysore

Dr. M. N. Sadaphal, Agronomist and Officer-in-Charge, PIRRCOM Center (Dhadesugur)
Shri P. V. Anantharaman, Agricultural Chemist, PIRRCOM Center (Dhadesugur)
Shri Masoom Hussain, Entomologist, PIRRCOM Center (Dhadesugur)
Shri S. R. Kaiwar, Head, PIRRCOM Subcenter (Dharwar)
Shri S. B. Priyavratha Rao, Head, PIRRCOM Subcenter (Bellary)
Shri K. Ramachandra Rao, Research Assistant, PIRRCOM Subcenter (Bellary)
Shri I. R. Morabad, Agricultural Demonstrator, State Station (Annigeri)
Shri Madhavorao, State Station (Siruguppa)
Shri M. Raghumurthy, Agronomist, State Station (Siruguppa)
Shri S. B. Puranik, State Station (Raichur)
Shri A. Padmanabha Rao, State Station (Hegari)
Shri C. M. Lamani, State Station (Bijapur)
Shri B. J. Patil, Plant Breeder and Officer-in-Charge (Bijapur)

Rajasthan

Shri M. P. Bhatnagar, Economic Botanist (Jaipur)
Dr. D. K. Misra, Agronomist, Central Arid Zone Research Institute (Jodhpur)
Shri B. H. Matai, Head, PIRRCOM Subcenter (Ajmer)

SEED PRODUCTION

Wayne H. Freeman, PH.D., Seed Production Advisor, The Rockefeller Foundation
Warren W. Sahs, M.S., Foundation Seed Production Specialist, The Rockefeller Foundation
Jack D. Traywick, M.S., Associate Agricultural Engineer, The Rockefeller Foundation
Shri D. S. Rana, Technical Assistant
Shri N. P. S. Chauhan, Technical Assistant
Shri S. S. Virdi, Technical Assistant, Agricultural Engineering

Indian Council of Agricultural Research

Dr. S. M. Sikka, Additional Agricultural Commissioner
Shri P. L. Malhotra, Administrative Officer
Shri B. M. Pal, Assistant Administrative Officer
Shri N. S. Gill, Assistant Seed Production Officer
Shri M. Sankara Rao, Assistant Seed Production Officer
Shri V. B. Malik, Assistant Seed Production Officer
Shri S. S. Bal, Assistant Seed Production Officer

Double-cross production field of Ranjit, a new maize hybrid.

Director's Introduction

Steady progress in all the projects, more than marked innovations, constitutes the distinguishing feature of the past year's work. The period covered by this report is also the first year of India's Third Five Year Plan. This Plan is an ambitious one, calling for an investment almost double that of the Second Plan. It recognizes the key role of agriculture in the developing economy and the need to increase production of food and other agricultural products as well as to provide for the training of scientific manpower and the development of research and extension programs. The industrial capacity for fertilizer production is to be doubled, and improved seeds of dependable quality are to be made available on a progressively increasing scale. These and many other features represent realistic approaches to the requisites of a more productive agriculture.

The four double-cross maize hybrids released in 1961 for the plains area and a fifth in 1962 for the Himalayan area give promise of contributing significantly to these Third Plan goals. To make improved maize hybrids available to plant up to one-fourth of the nation's present maize acreage by the end of this Plan period, the National Seeds Corporation is launching an ambitious program of seed production and quality control. Foundation and certified seed supplies are being increased as rapidly as seed stocks and trained supervision permit. Although only 6 acres were in double-cross production in the rabi 1960–1961 season, approximately 1,100 acres are to be grown in kharif, 1962. Performance of the hybrids, experience of seed growers in producing and distributing seed of high quality, and acceptance by farmers continue to be most encouraging.

The educational program introducing these hybrids stresses improved practices, including land preparation and drainage, proper spacing, fertilization, weed control, and attention to pests and diseases. Arrangements have been completed during the year for a substantial expansion of the research program to develop the necessary information backstopping the recommendations on these practices.

The research on sorghums and millets is moving toward identification of the hybrid combinations which can be depended upon for successful production under the conditions encountered in various parts of the country. Satisfactory hybrids must have not only good vigor and a high yield potential, but also a reasonable degree of tolerance to the attacks of insects such as the shoot fly and stem borer. They should also be resistant to the more prevalent leaf diseases and have an acceptable grain quality—generally a light color with a pearly endosperm. While no such hybrids have yet been released for general seed production and distribution, several very promising ones are now in advanced tests.

Comprehensive collections of the indigenous varieties and types of sorghums and millets have been made by teams covering systematically all the important sorghum-growing areas of the country. These collections, along with other materials obtained from Africa, the United States, and other parts of the world, are being studied, classified, and evaluated, and the more promising materials are being utilized in the breeding programs.

Significant progress has been made during the year in certain states in developing closer center-state cooperation in the sorghum and millets improvement programs, with the objective of getting the maximum combined results from the contributions of both agencies.

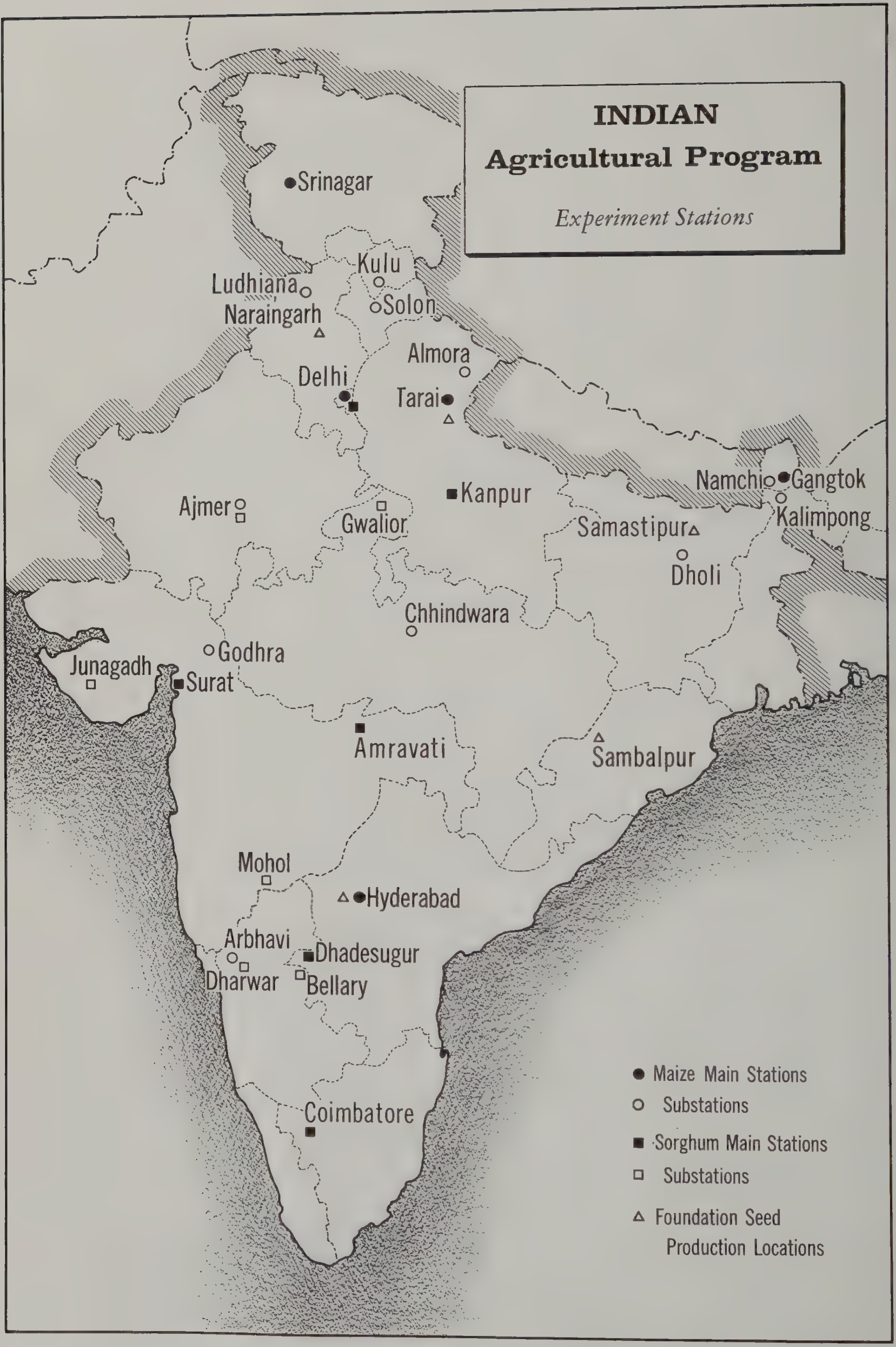
With the addition of an entomologist to the field staff, a vigorous approach is being made to one of the most serious problems limiting maize and sorghum production. Thus far, many encouraging leads have been obtained.

Support for experiment station operations has been increased during the year in recognition of the acute need to build other research programs on a base of good land management and the best farming practices. Priority is being given to land preparation and water control, especially land shaping to facilitate uniform distribution of irrigation water and effective drainage and disposal of excessive surface water.

The Post Graduate School of the Indian Agricultural Research Institute held its first convocation and awarded 16 Ph.D. and 112 M.Sc. degrees. Facilities for the library, cereal research laboratory, fundamental genetics, and horticulture have been completed and brought into use. Most of the authorized staff of the newly created Divisions of Extension Education and Agricultural Economics have been recruited, and while these divisions will have to await new construction before they have sufficient office and laboratory facilities, they are now in a position to move ahead on research and postgraduate training programs.

The IAP was especially fortunate in having the assistance of four visiting professors who served for limited periods with the Post Graduate School: Prof. Robert W. Hodgson, Horticulture; Dr. Homer D. Chapman, Soils and Plant Nutrition; Dr. Robert M. Hagan, Irrigation; and Dr. Milton Fireman, Salinity, Alkali, and Water Quality. We are also grateful for the services of Mr. Warren W. Sahs, Seed Production Specialist, and Mr. Ray E. Armstrong, Agricultural Engineer, who have been loaned to the IAP for a year by the University of Nebraska and the Iowa State University, respectively.

Again it should be emphasized that the great measure of progress noted is not merely in the physical achievements of the programs but also in the growing number of well-trained agricultural scientists who have a vision of what their country may become and a determination to devote their full talents toward its realization.



INDIAN

Agricultural Program

Experiment Stations

Cooperating Federal and State Experiment Stations and Foundation Seed Production Locations, Indian Agricultural Program.

Station	Size (acres)	Altitude (feet)	Av.temp.(°F.)		Av. rainfall (inches)	Soil types	Principal fields of investigation
			Max.	Min.			
MAIN STATIONS							
Amravati, Maharashtra	400	1,213	92.0	69.6	33.52	Black cotton	Sorghum
Coimbatore, Madras	600	1,400	89.3	69.9	23.23	Red loam	Sorghum
Delhi, Delhi	1,000	750	88.8	64.5	26.24	Alluvial—Silty	Maize; Sorghum
Dhadesugur, Mysore	322	1,161	92.5	71.8	25.54	Black cotton	Sorghum
Gangtok, Sikkim	6	4,500	77.0	59.0	150.00	Sandy loam	Maize
Hyderabad, Andhra Pradesh	120	1,760	90.4	68.4	29.42	Sandy loam—Clay loam	Maize
Srinagar, Jammu and Kashmir	60	5,200	67.8	43.9	25.99	Loam	Maize
Surat, Gujarat	158	19	91.5	70.4	41.67	Black cotton	Sorghum
U.P. Agricultural Univ. Pantnagar, Uttar Pradesh	16,000	800	87.6	65.0	42.65	Loam—Clay loam	Maize
SUBSTATIONS							
Ajmer, Rajasthan	200	1,595	88.2	65.2	20.77	Sandy loam—loam	Maize; Sorghum
Almora, Uttar Pradesh	12	4,200	63.5	50.1	87.60	Sandy loam—Clay loam	Maize
Arbhavi, Mysore	15	1,920	90.7	68.0	20.19	Sandy—Sandy loam	Maize
Bellary, Mysore	214	1,460	92.9	71.1	20.04	Black cotton	Sorghum
Chhindwara, Madhya Pradesh	6	2,236	88.3	63.7	57.55	Sandy loam—Clay loam	Maize
Dharwar, Mysore	800	2,200	84.7	64.1	50.93	Loam	Sorghum
Dholi, Bihar	240	160	86.9	67.2	49.81	Sandy loam—Loam	Maize
Godhra, Gujarat	6	1,001	91.0	67.1	28.15	Sandy loam—Clay loam	Maize
Gwalior, Madhya Pradesh	120	735	90.6	66.0	29.00	Alluvial	Sorghum
Junagadh, Gujarat	702	200	92.9	66.4	24.80	Loam	Sorghum
Kalimpong, West Bengal	12	3,500	70.1	58.3	86.20	Sandy loam	Maize

Station	Size (acres)	Altitude (feet)	Av.temp. (°F.) Max.	Min.	Av. rainfall (inches)	Soil types	Principal fields of investigation
SUBSTATIONS (*Cont.*)							
Kangra, Punjab	9	2,195	—	—	90.00	Clay loam	Maize
Lachung, Sikkim	—	8,500	—	—	60.00	Sandy loam	Maize
Mohol, Maharashtra	130	1,500	—	—	26.60	Black clay	Sorghum
Namchi, Sikkim	—	5,000	—	—	80.00	Sandy loam	Maize
Naraingarh, Punjab	400	800	88.1	63.6	27.21	Sandy loam	Maize
Solon, Himachal Pradesh	—	—	—	—	—	Sandy loam	Maize
FOUNDATION SEED PRODUCTION LOCATIONS							
Naraingarh, Punjab	19	800	88.1	63.6	27.21	Sandy loam	Maize
U.P. Agricultural Univ. Pantnagar, Uttar Pradesh	25	800	87.6	65.0	42.65	Loam—Clay loam	Maize
Hyderabad, Andhra Pradesh	5	1,760	90.4	68.4	29.42	Sandy loam—Clay loam	Maize; Jowar
Samastipur, Bihar	6	160	87.6	68.9	46.69	Loam	Maize
Sambalpur, Orissa	32	487	90.5	69.6	65.78	Sandy loam	Maize; Jowar

The Post Graduate Council entering Pandal, first convocation, IARI, Post Graduate School, December, 1961.

Agricultural Education

The first convocation for the award of M.Sc. and Ph.D. degrees from the Post Graduate School of the Indian Agricultural Research Institute (IARI) was held on December 26, 1961. The Minister for Food and Agriculture, Shri S. K. Patil, delivered the principal address and awarded the degrees. Sixteen students were awarded the Ph.D. degree and 112 students the M.Sc. As of April 30, 1962, an additional nine students had completed the requirements for the Ph.D. and an additional 56 the requirements for the M.Sc.

The present student body consists of 399 students, of whom 45% are Ph.D. candidates and 55% M.Sc. candidates. The faculty now has 131 members—71 professors and 60 assistant professors. Research and postgraduate teaching are fully integrated, with each faculty member being engaged in both instructional and research work.

During the year, most of the authorized staff of the two new Divisions of Agricultural Economics and Extension Education have been recruited. Although they must occupy crowded quarters until new facilities are constructed, these divisions are now prepared to offer a full program of training to students. The course offerings in these fields have undergone a full review and revision and have been enlarged and broadened.

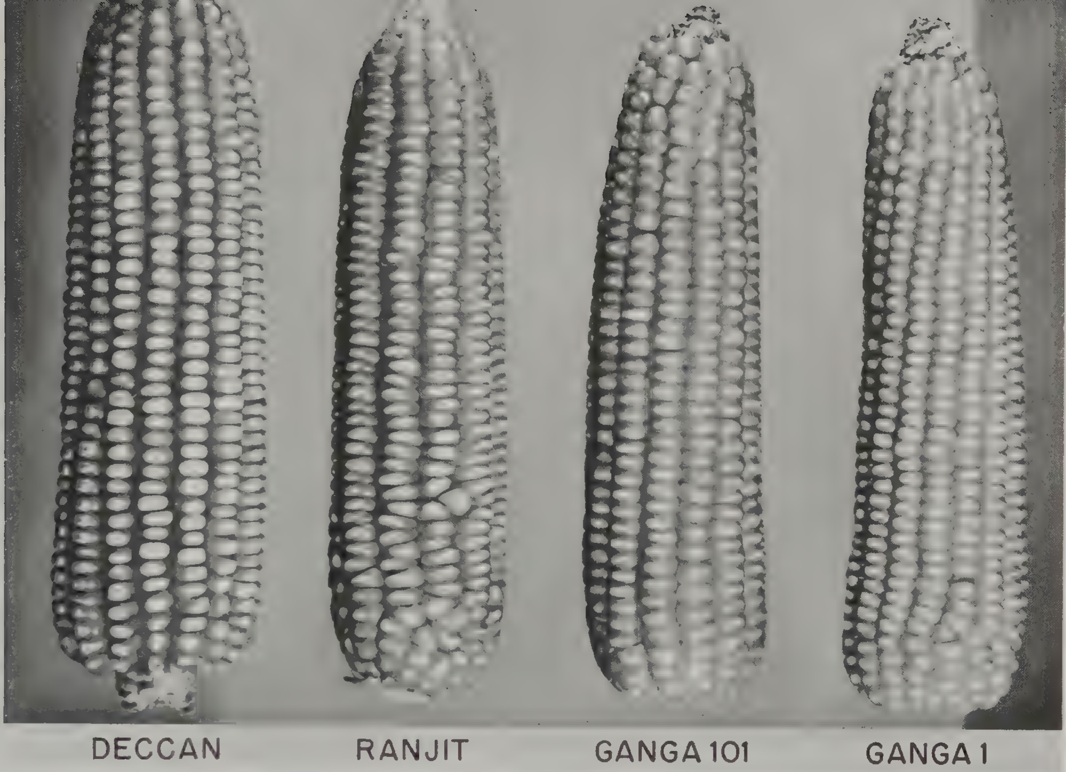
There have been a number of changes in personnel occupying key positions of responsibility in the IARI's program during the past year, in addition to the increase in staff for the new divisions and various replacements and promotions. Dr. S. Pradhan has been confirmed as Head of the Entomology Division, succeeding Dr. E. S. Narayanan, who retired. Dr. M. S. Swaminathan has been confirmed as Head of the Botany Division, succeeding Dr. A. B. Joshi, who is now Dean of the Post Graduate School. Dr. O. P. Gautam has been confirmed as Head of the Agronomy Division, after having served in an acting capacity since Dr. P. C. Raheja's departure to become

Director of the Central Arid Zone Research Institute. Dr. S. P. Raychaudhury, Chief Soil Survey Officer, joined the staff of the Planning Commission and his place has been taken by Dr. S. V. Govindarajan.

The postgraduate assistantships, which were initiated last year with a view to providing further support to the cereal improvement schemes, are proving useful as a means of strengthening postgraduate training. Eighteen students are now holding these part-time assistantships, distributed over six divisions of the IARI. Recognizing the value of this technique, the institute has been giving consideration to providing additional studentships along similar lines, with Government support.

The additions to the central library building at the IARI have been substantially completed. With the opening of these new units, which is expected to take place shortly, there will be comfortable reading facilities for about two-thirds of the student body at one time as well as direct and full access to the bookshelves and stacks. This will greatly extend and improve the usefulness of the library collection for both students and staff. The cereal research laboratory and the buildings for horticulture and fundamental genetics have been completed and are occupied.

The field director has continued to spend a considerable amount of time with the Agricultural University Committee of the Government of India. During the year, the States of Punjab, Orissa, and Rajasthan have enacted legislation providing for the establishment of agricultural universities with statewide responsibility for education, research, and extension. Four others have developed draft bills and proposals, and the committee has held extensive discussions with government officials in these states to assist them in preparing for legislative action. It is anticipated that these bills will be considered by the state legislatures during the course of the year. Preliminary correspondence and discussions have been held with four other states which are evincing positive interest in the subject. This movement would seem to hold considerable promise for a major advance in the organization and orientation of agricultural research and educational services in India.



India's new maize hybrids.

Maize Improvement Scheme

In reviewing the progress made by the Co-ordinated Maize Breeding Scheme since its inception, one can justifiably say that the year 1961 was a landmark in its five-year history. Four top-performing double-cross hybrids were released for commercial production and distribution to farmers in the northern plains and peninsular India. As the production and distribution of hybrid seed to the farmers gather momentum in the coming years, these hybrids should make a significant contribution toward increased food production in the country.

A note of caution should, however, be added here. Potentially top-performing hybrids in themselves are by no means the complete answer. Their cultivation must be carried out under improved and recommended agronomic practices. Although considerable practical information is available on hybrid maize culture, the optimum conditions suited to Indian climate and soil have still to be determined. It is, therefore, gratifying to record that plans are being formulated for intensifying research in agronomy and other cognate sciences such as entomology and plant pathology within the framework of the maize scheme. Maize breeders can thus look forward to an era of greater progress in collaboration with scientists of related disciplines.

During the past year, primary effort has been devoted to developing medium-maturing hybrids for the Indo-Gangetic plains and white varieties for areas where white grain is preferred, and to plant population and fertility level studies. Considerable attention was also given to materials adapted to the Himalayan Range.

PERSONNEL AND FACILITIES

Although the staff and facilities at most of the stations have remained the same, the stations at Delhi and Tarai have experienced several personnel changes during the year. At Delhi, Dr. Paliwal, Dr. Mehra, and Mr. Dayani have become Senior Maize Breeder, Junior Maize Breeder, and Research Assistant, respectively. With the integration of the maize project with the U.P. Agricultural University, the Tarai program has lost two research assistants and most of its subordinate staff to the Uttar Pradesh Government; it is understood that the university will be appointing new staff very soon. Dr. N. N. Roy has resumed his responsibilities at Kalimpong after completing requirements for the Ph.D. degree at Cornell University.

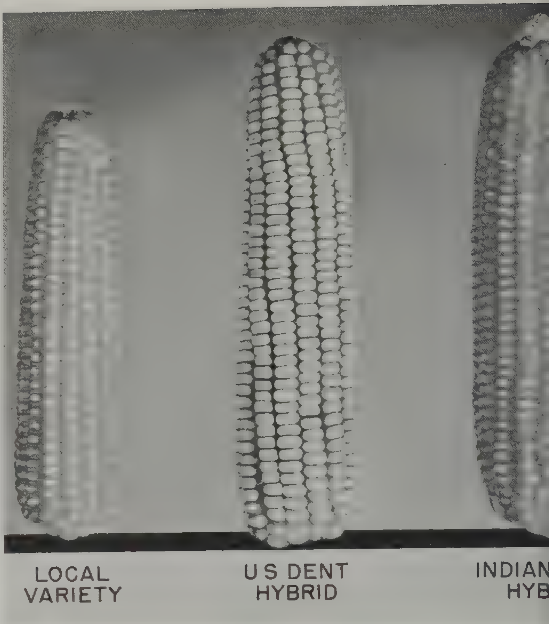
The only major change in facilities was the complete mechanization of the Naraingarh station. Requisitions have also been placed for mechanizing Dholi.

The two stations in the Punjab were relocated at the end of the maize season. The Naraingarh station was shifted to Ludhiana and incorporated into the Punjab Agricultural College Experiment Station. A great deal of effort was devoted to development of the land on this new station. The Kangra station was shifted to Bajaura in the Kulu Valley, a location which should prove a great asset in maize improvement for the Himalayan Range.

The maize scheme personnel at the IARI have moved into the new cereal research laboratory. The added space and facilities are being well used and the staff are looking forward to the completion of the installations in this building.

BREEDING

The breeding work during the year has been devoted primarily to maintaining the lines available and developing new combinations to thoroughly evaluate the existing materials before starting a new cycle of breeding. In addition, considerable effort was applied to the development of new germ plasm complexes that will be used in various breeding programs in the future.



Ears of the local variety Basi, U.S. dent hybrid Texas 26, and Ganga 101.

The breeders have been actively engaged in increasing breeder seed of the ten inbred lines making up the new hybrids, Ganga 101, Ganga 1, Ranjit, and Deccan.

FIELD TRIAL RESULTS

Yield trial testing progressed to the first inclusion of double-cross hybrids, double-topcross hybrids, and synthetics developed within the Coordinated Maize Breeding Scheme. The trials were conducted at 15 locations (Srinagar, Almora, Kalimpong, Kangra, Sikkim, Solon, Delhi, Ajmer, Naraingarh, Tarai, Dholi, Hyderabad, Arbhavi, Chhindwara, and Godhra) and involved 47 different sets of material in 122 separate yield tests, the largest in the history of the maize scheme.

DOUBLE-CROSS TRIALS

A total of 112 experimental double-cross hybrids were tested in kharif, 1961. The inbred lines in the pedigrees of these hybrids originated from material of diverse sources, including India, the Caribbean, and North and South America.

TABLE 1.

Comparison of yields (kg./ha. at 15% moisture) of recommended and experimental maize hybrids. 1961.

	ZONE 2[a]			ZONE 3			ZONE 4			
Hybrid or variety	Yield	% of local	Days to flowering	Yield	% of local	Days to flowering	Yield	% of local	Days to flowering	Av. yield 3 zones
Local	2,683	100	51	3,120	100	59	4,066	100	62	3,395
Ganga 1	3,367	125	52	3,887	125	54	4,547	112	53	4,007
Ganga 101	3,691	138	58	4,521	145	61	5,182	127	61	4,538
(Cuba 342 × CI21E) × (Dix18 × PH3)	3,949	147	54	4,953	158	56	5,286	130	58	4,766
Local	2,542	100	53	3,113	100	60	3,788	100	53	3,223
Deccan	3,718	146	57	5,032	162	60	4,897	129	62	4,534
Ranjit	3,270	129	59	4,344	139	61	4,607	122	61	4,103
(CI21E × G715-1) × [(Venz 1 × Venz 400-#) × Peru 330]	4,144	163	57	4,746	152	59	5,644	149	61	4,944

[a] Zone 2 = Dry Gangetic Plains; Zone 3 = Wet Gangetic Plains; Zone 4 = Peninsular India. Foothills of the Himalayan region constitute Zone 1.

As shown in Table 1, the two hybrids, (Cuba 342 × CI21E) × (Dix18 × PH3) and (CI21E × G715–1) × [(Venz 1 × Venz 400-#) × Peru 330], may have real promise for the plains of India. The first is three to five days earlier than Ganga 101 and gave superior performance in Zones 2 and 3, where Ganga 101 is recommended. In Zone 3 it is actually earlier than the local variety, a fact of paramount importance since the farmers of this zone who grow yellow maize insist on the earliest possible varieties. The second hybrid, although slightly later than the first, appears to be a better performer in Zones 2 and 4. The two sections of Table 1 are not directly comparable because the data are from different trials, but judging on the basis of all the data available within the maize scheme, Ganga 101 is slightly superior to Deccan in the plains and peninsular India. These two experimental hybrids may therefore prove to be superior to the presently available hybrids.

Several other experimental hybrids have performed well, but at least one more year's data will be obtained on an all-India basis

Seed producers and cultivators discuss relative merits of the new hybrids.

TABLE 2.

Comparison of yields (kg./ha. at 15% moisture) of six white maize hybrids. 1961.

Hybrid or variety	ZONE 2 Yield	ZONE 2 % of local	ZONE 2 Days to flowering	ZONE 3 Yield	ZONE 3 % of local	ZONE 3 Days to flowering	ZONE 4 Yield	ZONE 4 % of local	ZONE 4 Days to flowering
Local	2,639	100	51	2,406	100	60	3,199	100	56
(Eto PL-13 × Tenn29) × Rudrapur	4,072	154	57	4,426	184	59	4,443	139	59
.. × Pusa Cult	3,777	143	55	4,160	173	57	4,228	132	59
.. × Indore State	3,706	140	52	3,424	142	57	4,552	142	55
.. × Kalimpong type	3,550	135	56	3,818	159	60	4,544	142	59
.. × Jelicose	3,628	137	58	3,346	139	63	4,307	135	62
.. × Malan	3,871	147	57	3,086	128	62	4,978	156	60

before definite conclusions are drawn. In the Himalayan area the two hybrids, (Desc 2 × Eto-190C) × (Kys × CI21E) and VL 54, appear to have the widest range of adaptation. It seems probable, however, that the agro-climatic variation within the Himalayan Range will necessitate the release of more than one hybrid for Zone 1.

DOUBLE-TOPCROSS TRIALS

Ten white varieties were crossed to the white single cross, Eto PL-13 × Tenn29, to meet the demand for white hybrids in India. Table 2 presents yield data for six of these hybrids for one year within three zones. For those areas requiring white flint material, the hybrids with Rudrapur and Indore State appear to be the best, although the hybrid with the Kalimpong type cannot yet be ruled out. In the one area that requires a white dent, both Jelicose and Malan appear to have promise as germ plasm. These white dents may also find a place in industrial use.

As shown in Table 3, Jelicose germ plasm may also fill the demand for white maize in Kashmir. Although the people prefer flint grain, US 13, a yellow dent, has found favor in this area and the introduction of a white dent may therefore not be too difficult.

Twenty-two high-yielding, yellow grained single crosses from Zone 2 were topcrossed to Basi, a yellow grained local variety grown in the northwestern plains of India, and the resulting hybrids were tested at all locations in Zone 2. All hybrids outyielded the local variety by at least 30% and eight yielded 50–70% more than the local.

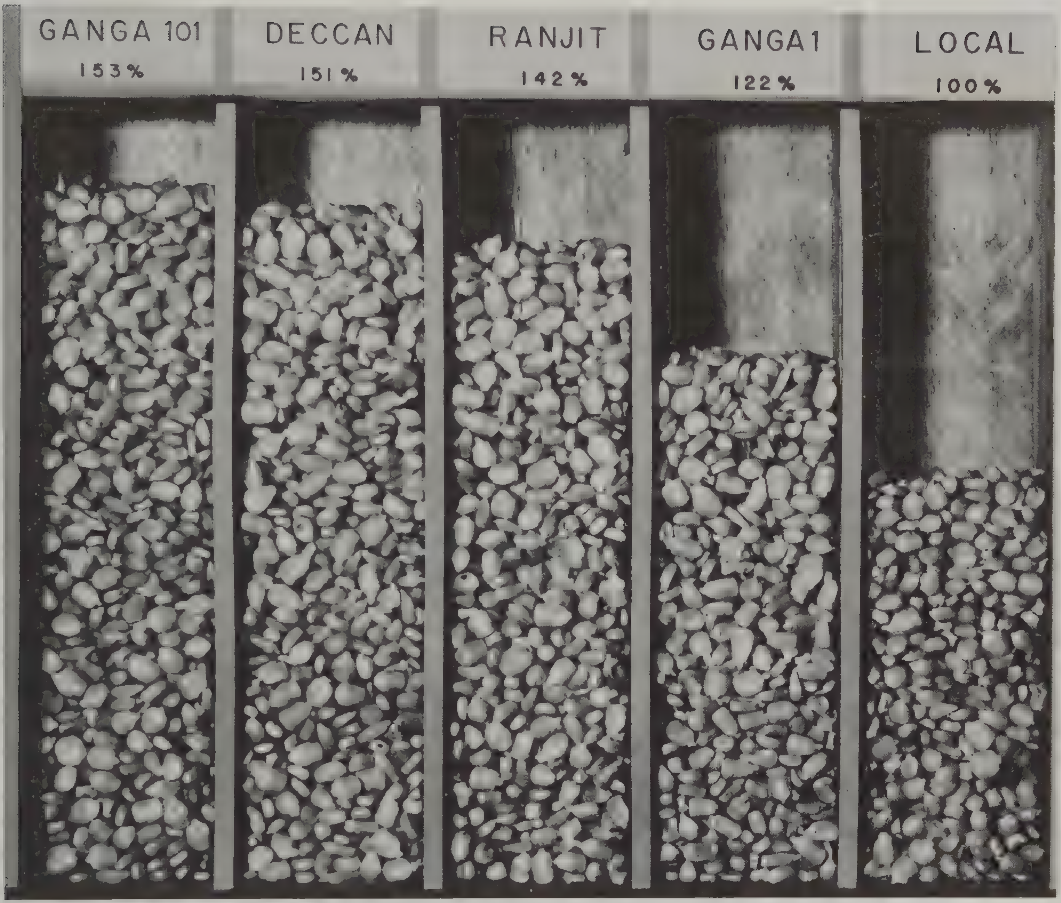
SYNTHETIC TRIALS

Several outstanding inbred lines that have been identified in the maize scheme are the parental material in 13 experimental synthetics that were tested at 11 stations. Although the performance of the synthetics was generally inferior to that of double-cross or

TABLE 3.

Comparison of yields (kg./ha. at 15% moisture) of a white dent hybrid and the local variety. 1961.

	SRINAGAR Yield	SRINAGAR Days to flowering	SOLON Yield	SOLON Days to flowering
Local	2,750	82	4,770	72
Jelicose × (Eto PL-13 × Tenn29)	5,187	95	5,867	72



Average yields of four new maize hybrids in percentage of local variety at 33 locations.

double-topcross hybrids, three synthetics outyielded the best local varieties by over 30% in Zones 1 and 4, two by 20% in Zone 2, and two by 50–63% in Zone 3. These results represent only one year's data but nevertheless are encouraging for the possibility of developing improved varieties for farmers in areas where seed distribution is difficult.

SINGLE-CROSS TRIALS

Trials that included double crosses and their parental and non-parental single crosses were seeded at Delhi, Naraingarh, Tarai, and Dholi. These trials were designed to obtain information as to the reliability of predicting the performance of double-cross combinations from single-cross data under Indian conditions. Close agreement was obtained between actual and predicted yields, days to flower, and several other characteristics.

Two single-cross trials were grown at all locations in Zone 4, one trial at two locations in Zone 1, and one trial at Ajmer. Many of these single-cross combinations yielded significantly more than the local variety: 20 out of 42 were superior at Ajmer; 12, 86, 48, and 68 out of 90 at Hyderabad, Arbhavi, Chhindwara, and Godhra, respectively; 26 out of 43 at Srinagar; and 34 out of 45 at Sikkim. These trials were also grown in kharif, 1960, and the two years' data were considered for the prediction of several double-cross combinations. These new combinations are being made during 1961–1962 rabi for inclusion in 1962 kharif trials.

TOPCROSS TRIALS

Results of the 23 topcross trials grown during kharif, 1961, confirm the finding of previous years that many of the inbred lines possess good combining ability. In these trials, 23% of the topcross hybrids were statistically superior in yield to the tester parent. Seventy-two out of 281 topcross combinations were superior to the tester parent in the hilly regions of the Himalayas, 80 out of 258 in the northwestern plains, 21 out of 301 in the northeastern plains, and 39 out of 67 in peninsular India.

Agronomic Studies

In past years a small amount of agronomic work was done using U.S. hybrids and local varieties. This year, however, studies have been carried out with the newly released hybrids and local varieties.

In order to obtain better information on the area of adaptation of the new hybrids as well as bring them to the notice of the farmers, 33 advanced trials were conducted. Each consisted of two replications and two levels of N, 45 and 112 kg./ha.; K_2O and P_2O_5 were applied uniformly at 45 and 67 kg./ha., respectively. As the trials were conducted on Government farms other than maize research stations, the data should be an indication of what could be accomplished by Indian cultivators.

Ganga 101 was the highest yielding hybrid on an all-India basis and also showed the greatest response to the higher level of fertility. Next in yield as well as response to the higher level of nitrogen were Deccan, Ranjit, Ganga 1, and the local varieties. Actually, the response of the local varieties to 112 kg./ha. of N was not large enough to be economical.

Ganga 101 yielded 4,041 kg./ha. of shelled grain at 15% moisture with a profit of Rs. 1,106.56 above seed and fertilizer costs. The highest recorded yield of 6,888 kg./ha. was obtained from Ranjit.

The target set by the Government of India is to plant 25%, or 2,500,000 acres, of India's maize acreage to hybrids by 1965. If this acreage were planted to Ganga 101 and yielded 4,041 kg./ha., it would return a value of Rs. 892,775,000 as compared with the present return of Rs. 250,000,000 on this area. Of equal importance is the fact that the present return could be increased to Rs. 475,775,000 if local varieties were fertilized with 45 kg./ha. of N.

Although the above data indicate a great potential for high-yielding varieties of maize, data from agronomic studies suggest that this could be even greater if better agronomic practices were followed. The average yield of Ganga 101 grown at Naraingarh, Tarai, and Dholi with 134 kg./ha. of N balanced with K_2O and P_2O_5 was 5,723 kg./ha., which gave a return of Rs. 1,516 per ha. after seed and fertilizer costs were subtracted. This yield is greater than the one cited above in part because these locations are in the area of adaptation and in part because better agronomic practices were followed.

Training Program

As in past years, a short course in maize breeding and seed production was held at the IARI. The course this year was extended from six to seven months to allow the trainees to take active part in preparation of the progress report.

At present there are ten postgraduate students with theses on maize supported by Rockefeller Foundation assistantships. These students represent the Divisions of Botany, Agronomy, Mycology and Plant Pathology, and Soil Chemistry. Several other students are working on maize in the various divisions.

Storing processed seed.

Seed Production

With the appointment of a special committee in January, 1960, the Government of India has been progressing toward the formation of a Seeds Corporation which would guide, finance, and stimulate the production and use of high-quality seeds of maize, sorghum, and other crops. At the request of the Ministry of Food and Agriculture, The Rockefeller Foundation agreed to assist in the development of the corporation by making available technical experts and providing a limited amount of equipment.

During the year the following steps have been taken: the name "National Seeds Corporation" has been selected; the Articles and Memorandum of Association under the Indian Companies Act have been drafted; the financial structure for the Third Plan period has been developed; the composition of the Board of Directors and the initial organizational structure have been decided; and some staff have been recruited as seed production officers at the foundation seed units.

The release of four maize hybrids in 1961 emphasized the urgent need for the corporation. Pending its formation, the ICAR personnel have taken the leadership in getting seed production under way. In kharif, 1961, double-cross maize seed was grown by six producers in five states—Punjab, Bihar, Rajasthan, Gujarat, and Andhra Pradesh. About 3,800 bushels of processed seed were obtained from 130 acres. During rabi, an additional 74 acres were grown with an estimated yield of 3,400 bushels.

Foundation seed production was carried out at four locations in kharif and three in rabi. During kharif, seed was grown at the U.P. Agricultural University Farm, Tarai; the Maize Seed Farm and Maize Research Farm, Naraingarh, Punjab; and the Rajendranagar Farm, Hyderabad, Andhra Pradesh. During rabi, seed was produced at the Messina Society Farm, Samastipur, Bihar; a state farm in the Sambalpur District, Orissa; and the Rajendranagar Farm in Andhra Pradesh. The single crosses and the necessary inbred increases were produced on 48 acres in the kharif season and on 42 acres in the rabi season.

Sufficient foundation seed is now available for planting 1,100 acres in the 1962 kharif season, with some carryover for some of the hybrids. Plans call for four foundation units to be established during the next five years, three of these to be established immediately.

Double-cross production is being packaged in printed cotton bags in amounts sufficient for 1 acre (12 pounds) and 2 acres (24 pounds). The bags are machine sewed, tagged, and sealed. The fact that seed is packaged so as to suit more nearly the needs of the individual cultivator has proved to be a popular feature. Each bag contains a set of instructions in two languages briefly describing improved cultural practices.

The season's production provided valuable training for personnel in seed production, seed certification, drying and processing, storing, and inbred line maintenance.

At a maize seed producers' conference held for growers of the 1961 production and prospective new growers, keen interest was expressed in continuing and expanding hybrid maize seed production. The booklet, "Improved Agricultural Seeds," was revised and presented at the conference. The role of private enterprise is being given a more prominent position in the production, processing, and distribution of hybrid seed, and promotional programs have been developed for stimulating seed producers to become seed merchandizers. In the past, distribution systems have usually depended upon the facilities and financing of state departments of agriculture.

In view of the expanding production, the problem of acquiring the necessary processing machinery has been studied and equipment specifications developed. Equipment for land shaping, seed drying, and seed processing is not available in India and must be imported.

The number of personnel for the seed production program has been increased to include specialists in foundation seed production and in equipment for production and processing. Six Indian employees have been spending full time on seed production.

Pearl millet (bajra) is highly susceptible to bird attack.

Sorghum—Millet Improvement

The estimated sorghum and millets production in India for the crop year 1960–1961 was 15.8 million long tons of grain, grown on 88.2 million acres. This production constituted 23.7% of India's total cereal grain production and 39.7% of the cereal acreage. A considerable acreage of sorghums, however, and to a lesser extent pearl millet, was cultivated primarily for fodder. Sorghums contributed most to this production, being cultivated on 42.1 million acres yielding a total of 9.1 million tons of grain.

In the sorghum breeding program more than 558 different hybrid combinations were developed and tested during the past kharif (summer monsoon) and rabi (winter) seasons: 208 hybrids were included in replicated trials, and 350 new test crosses were evaluated in single-row observation plots at two or more locations. During the 1961–1962 rabi season at Dhadesugur (Mysore), 256 selected hybrids were tested in replicated trials.

Coordination

The establishment of several PIRRCOM (Project for the Intensification of Regional Research on Cotton, Oilseeds, and Millets) stations with attendant facilities and staff during the period from late 1960 to early 1962 has provided the means for expanding millet improvement. Primary emphasis during this time has been placed on developing and testing hybrid sorghums.

Progress has been made in developing closer center-state collaboration in sorghum improvement. Millet specialists from the States of Madras and Mysore participated with PIRRCOM personnel in selecting materials and hybrids in the extensive nurseries and hybrid trials at Coimbatore and Dhadesugur for breeding and testing in the subsequent season. Plans have been developed and approved for expanded programs at these stations and at Dharwar (Mysore) and Surat

(Gujarat). Other states have indicated an interest in a more integrated program and are arranging to carry out trials of promising hybrids and strains they have helped select.

SORGHUM IMPROVEMENT

Sorghum breeding and testing were concentrated at four main centers, but five other PIRRCOM stations and eight state-supported stations collaborated in conducting trials and related investigations.

Nurseries and yield trials were planted in both summer (February–June) and monsoon (August–December) seasons at Coimbatore; in the monsoon season at Surat, Dharwar, and the IARI; and in rabi at Dhadesugur.

Generally, there were between 800 and 2,300 entries in the nurseries and between 150 and 200 entries in the trials, the majority of which were hybrids. In both the nurseries and trials 15–20% of the lines and entries were selected for continued improvement and evaluation. Selection was based primarily on actual yield data from the trials and visual selection notes jointly taken by state-center personnel at Coimbatore and Dhadesugur. From the observations made at Coimbatore, three hybrids were selected for statewide testing in Madras during the 1962 monsoon season, and at Dhadesugur 18 hybrids were selected for statewide testing in Mysore during the rabi season of 1962–1963. Hybrid fodder sorghum trials will be carried out in Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan, and Punjab, and advanced trials of hybrid sorghums have been requested by Andhra Pradesh, Gujarat, and Rajasthan for the 1962 monsoon season.

The variation due to error decreased in trials at Coimbatore and Dhadesugur this year, averaging about 20%. At both locations reasonably good levels of production were attained. Yields of the more promising hybrids grown at Coimbatore were about 3,000 kg./ha. as compared with about 1,500 kg./ha. for the local variety checks; at Dhadesugur the more promising hybrids yielded about 2,500 kg./ha. and local variety checks were about 75–80% of the better hybrids. Plans

The red-seeded grain hybrid RS 610 has excellent adaptation over a wide range of conditions in India and has been used extensively as a check in yield trials.

have been made for growing a green manure crop at these locations and for land leveling at Dhadesugur to further improve the trials. In a good, but small, trial grown at Hyderabad during the rabi season, the hybrids yielded about 4,000 kg./ha. and the local variety check about 2,000 kg./ha.

All hybrids have Male Sterile Kafir 60 (Line 385) as the female parent. Satisfactory male parents come primarily from indigenous varieties, although the zerazera group from Africa and a number of yellow endosperm types (especially Hegari) from the United States result in very acceptable grain hybrids. Hybrids involving all these types were the ones selected for statewide testing in Madras and Mysore. The two identified at present as having regional promise are M.S. Kafir 60 × Karad Local and M.S. Kafir 60 × Maldandi 35-1. Both of these male parents are of Indian origin.

The crop at Delhi included many varieties and hybrids which were found to be unadapted; frequently, flowering was late; growth rank, and lodging excessive. Sorghum is not used as a food grain in this area, and locally adapted types suitable as parents for quality grain hybrids are few. Fodder sorghums, however, are very important and profitable, and several hybrids show outstanding promise in this respect. It is likely that a well-adapted, high-yielding grain hybrid—dwarf or semi-dwarf in height—would be very useful in North India. Evolved grain hybrids for this area, however, will have to compete as introductions with other cereals, primarily pearl millet.

The crossing block for all stations has been consolidated at Coimbatore for most effective handling. Since the summer growing season for crops at Coimbatore does not coincide with the growing season of any other part of the country, varieties selected in one season can be crossed and evaluated as hybrids in the next. Likewise, the backcrossing program for producing new cytoplasmic male-sterile females has been accelerated in an attempt to produce three generations each year, at least in early maturing strains. During the 1962 season some 15,000 cross-pollinations were made to produce seed for yield trials at other stations.

The early maturing fodder strain Sundhia 1049 has excellent adaptation and resistance to stem borers.

MILLETS CONFERENCE

The 2nd All India Millets Conference was organized and held at Kanpur, U.P., on September 20–23, 1961. This meeting was attended by millet specialists and members of supporting disciplines from the millet-growing states and PIRRCOM centers and subcenters in India.

The status of millet improvement in the important millet-growing region was reviewed by representatives of those states and special sessions were held covering the following subjects: developing hybrid sorghums and pearl millets; major pests and diseases of millets and progress made in controlling them; special problems including breeding for high fertility conditions, drought resistance, and grain quality; genetic and cytogenetic studies; agronomic aspects; and coordination of research.

A plenary session was held on the final and fourth day of the conference summarizing the information presented and formulating a number of resolutions toward coordinating and implementing millet improvement on an all-India basis.

PENNISETUM IMPROVEMENT

Pennisetum typhoides, like sorghum, is an important dual purpose (food and feed) monsoon crop in India. It is widely cultivated under rainfed conditions on soils either too poor or too deficient in moisture to support other crops. It occupies about 28 million acres of cultivated land and is the fourth major cereal crop of the country (after rice, sorghum, and wheat).

Recommendations have been made to the Government of India for intensifying efforts on pearl millet improvement on an accelerated basis. This program would feature the development and testing of hybrids produced with the genetic mechanism, protogyny, or with cytoplasmic sterile lines. Recent introductions of cytoplasmic sterile and genetic dwarf lines from Georgia (U.S.A.) provide some valuable germ plasm for expanded breeding efforts. Pearl millet improvement programs are being developed at the IARI and at the PIRRCOM stations at Coimbatore, Kanpur (U.P.), and Ajmer (Rajasthan). Coordination of an expanded pearl millet improvement program would follow closely the pattern adopted for sorghum improvement with the exception of specific breeding techniques which in this case must apply to a cross-pollinated crop.

Recently, through the millets collection program, an extensive collection of *Pennisetum* germ plasm has been obtained from both indigenous and exotic sources. This material, presently exceeding 1,300 samples, is being classified for various desirable characters such as early maturity, awns, tillering, bolder grains, and resistance to green ear and smut diseases.

COLLECTION OF MILLETS

Field collecting during the third and concluding season was resumed in late September and early October, 1961, in the States of Jammu and Kashmir, Himachal Pradesh, Northern Punjab, Eastern Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, and Assam and the Union Territories.

This first phase of the systematic field collection of sorghums, millets, and maize will be completed by May 31, 1962, and will have resulted in more than 6,000 Indian collections of these crops. Individual collections of sorghum and millets on hand at the IARI as of February 15, 1962, are as follows:

Origin	*Sorghum*	*Penni-setums*	*Small millets*[a]
India			
Strains	362	246	8
Systematic collection	2,002	564	1,717
U.S.A.	1,325	241	58
Africa	767	291	38
China	30	—	30
Other countries	30	—	178
	4,516	1,342	2,029

[a] Small millets include *Eleusine corocana, Setaria italica, Panicum miliaceum, P. miliare, Echinocloa, Paspalum scrobiculatum,* and related species.

Three separate projects have been developed for classifying, evaluating, cataloguing, maintaining, and distributing these collections. This program, as submitted for support under Public Law 480 financing, would require five years to complete. All of the collected sorghum germ plasm is being systematically evaluated as a separate phase of the breeding program under "nursery introductions." A substantial number of these collections have been advanced to testing in hybrid combinations with male steriles. Some of these in the elite Maldandi group are sterilizable and therefore potential seed parents for new hybrids.

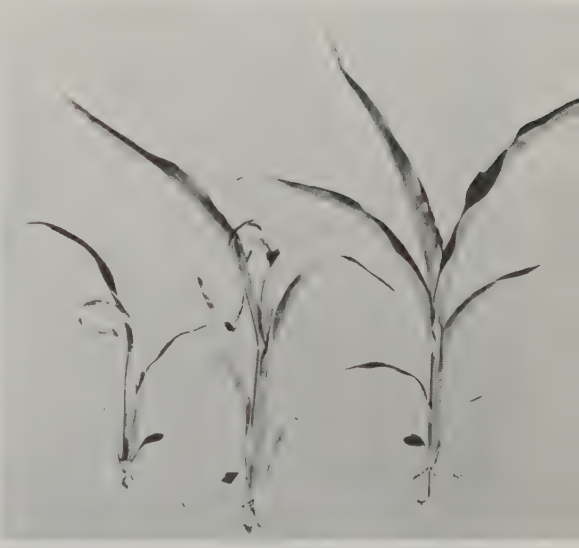
MANAGEMENT INVESTIGATIONS

Nitrogen fertilization has been found very beneficial to sorghum development at several locations. At Mohol (Maharashtra) in irrigated rabi sowings with the widely adapted Maldandi 35-1, 90 lb./A. of N increased grain yields by 60% and fodder yields by 29%. On rainfed fodder sorghums at Delhi, an application of 80 lb./A. of N on the experimental hybrid SH 10 resulted in a yield of about 51,500 lb./A. of green matter, exceeding the better of two local varieties at the same level of fertility by 69%. The gross income from this crop sold as green fodder would exceed the estimated costs for hybrid seeds, fertilizers, and land preparation by Rs. 400 to 700 at prevailing marketing rates. Since this was a three-month crop sown in July, the additional possibility of sowing in March or April with irrigation, harvesting the first crop at the end of June, and ratooning a second crop during the monsoon appears feasible and is presently being investigated. Besides SH 10, sudangrass hybrids with M.S. Kafir 60 are under study; these have the advantages of rapid growth and good recovery after clipping, and produce fine-stemmed, leafy fodder.

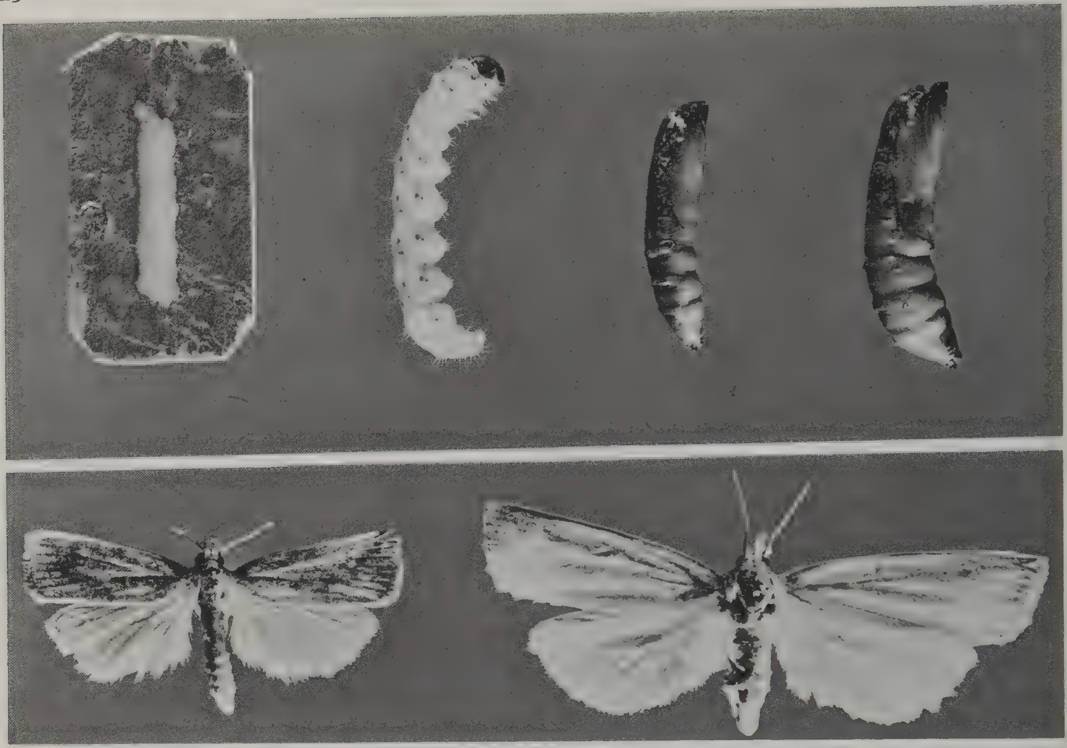
Weedicide trials in 1961 indicate the possibility of controlling several grassy and broad-leaved weeds (but not nutgrass) on sorghums and pearl millet with pre-emergence applications of Propazine and simazin at rates of 2 and 4 lb./A.

ENTOMOLOGY

Three insect pests are of major importance on the sorghum crop in India: the stem fly, *Atherigona indica* M.; the stem borer, *Chilo zonellus* S.; and the midge, *Contarinia* sp. As potential yields of sorghum are increased through the introduction of improved varieties and hybrids and the use of more efficient cultural practices, it becomes increasingly important that control measures be developed to reduce losses due to these insects. Preliminary field trials were initiated during the past year to evaluate various insecticides for the control of stem fly and stem borer, and the screening of sorghum varieties for stem borer tolerance was continued. At Delhi these activities were undertaken in cooperation with the Entomology Division of the IARI.


Typical injury caused by the sorghum stem fly. The central shoot has been cut by fly larva, tillers are developing on the two plants on the left, and the plant on the right is injured.

The stem fly, *A. indica*, attacks the seedling plants through the six-leaf stage of development, depositing eggs individually on the underside of the leaves. The resulting small larva penetrates the stem and cuts through the main shoot, producing a dead heart. Smaller plants may be killed and even though slightly larger plants generally survive and produce tillers, these mature later than the regular crop and yield less grain. Foliage insecticides have in general been ineffective against the stem fly since the larvae are exposed to them very briefly. A promising lead toward control of this pest was obtained, however, in a preliminary trial at Ajmer where the systemic insecticide, phorate, applied to the seed furrow in a 10% granular formulation at the rate of 0.5 g. per foot of row afforded almost complete protection to Verawal Dholio sorghum: 3–5% of plants with dead hearts as compared with 55–80% in untreated plots. Grain yields were increased from 21 kg./ha. in the control plots to 448 kg./ha. in the phorate treated plots. Similar control has been obtained at Coimbatore in South India.



Developmental stages in the life cycle of the jowar stem borer *C. zonellus:* egg mass, fully developed larva, male and female pupae, and male and female adults.

The stem borer, *C. zonellus*, generally attacks sorghum after the six- or seven-leaf stage. Eggs are deposited in masses on the underside of the leaves. The larvae migrate to the whorl to feed and as they penetrate deep in the whorl the main shoot is often destroyed and a dead heart results; the affected plants are thus removed from production. Properly timed insecticide application to the plant whorls can kill the small larvae of the stem borer and prevent dead heart injury. In replicated trials at Delhi conducted during July and August on the variety Redbine 58, four spray applications of Sevin (1.5 kg. actual/ha.) to the foliage at weekly intervals starting 15 days after planting reduced dead heart injury to 2.6%, while 41% of plants in untreated plots were damaged. Endrin spray (0.2 kg.), endrin granules (0.2 kg.), endrin on a wheat bran carrier (0.2 kg.), parathion spray (0.5 kg.), BHC spray (0.2 kg. gamma), BHC dust (0.5 kg.), and phorate granules (0.5 kg.) reduced dead heart injury to levels between 10% and 15%. Further studies are needed on the timing and economics of insecticide applications for borer control.

The incorporation of borer tolerance in improved varieties and hybrids also appears promising. More than 1,000 varieties have been screened for borer susceptibility in the field at Delhi, 125 of these in replicated trials. A few consistently exhibited less borer attack and injury, and may be good sources of germ plasm for borer tolerance.

The sorghum midge, *Contarinia* sp., attacks the developing earhead. The adult flies deposit their eggs in the glumes and the maggots destroy the developing seeds. Damage is probably more severe in breeding nurseries, where a wider variation exists in flowering date, than in commercial fields where the majority of developing earheads mature simultaneously. At Delhi, repeated application of DDT dusts and sprays to the earhead before flowering afforded effective control of the midge in the breeding nursery and yield trials during the 1961 kharif season.

BIRDS

Next to insects, birds are by a considerable margin the most important pest of the millets, particularly in the breeding fields at the IARI located close to the densely wooded city of Delhi. Bird pressure is so heavy in these fields that even the regular practice of posting up to eight bird scarers in a 12-acre field did not effectively deter depredations, especially by sparrows, parakeets, and doves. Spraying the ripening earheads with a 0.13% solution of endrin resulted in an estimated 50–70% control but caused certain undesirable side effects, including hazards in working with the crop. A 2% solution of thiram applied to the earheads appeared to have good repelling qualities, but BHC, lindane, and DDT applications were relatively ineffective.

Feeding different baited preparations of various grains in the off-season appears to be a useful practice in reducing bird numbers. Spreading popped sorghum, pearl millet, and rice treated with crude sugar along the field boundaries for several days, followed by baiting with a 1% mixture of endrin, has helped to reduce and repel certain bird species, particularly crows. The use of carbide exploding devices appears beneficial in a localized area of 1 to 2 acres for each such device. Trapcropping with pearl millet of varying maturities on the side of the field between the experimental crop and the major source of birds was demonstrated to be helpful owing to zone feeding habits of certain species, such as sparrows.

STUDENT GUIDANCE AND BASIC INVESTIGATIONS

Several students of the Post Graduate School at the IARI have elected thesis problems on sorghums and millets in partial fulfillment of the requirements for advanced degrees. Each year ten research assistantships are granted to qualified students in support of the maize and sorghum improvement projects.

Specific problems under study by graduate students include management of fodder sorghums, insect resistance in sorghums, systemic insecticide residues on millets, nematodes on millets, occurrence of leaf and other diseases of sorghum in India, combining ability studies in sorghums with reference to the use of male steriles, variation of grain quality in Indian sorghums, and factors affecting pollination of male-sterile sorghums. A study on combining ability of exotic and indigenous sorghums has been submitted and accepted in partial fulfillment of the requirements for the M.Sc. degree in Botany. Another study on rate of sowing and level of fertilization for fodder sorghum hybrids and varieties is nearing completion and has yielded some very interesting information substantiating the potential for hybrid fodder sorghums grown under relatively high levels of fertility.

Shaping land for effective water distribution and drainage at the Punjab experiment station.

Experiment Station Operations

Land shaping has received major emphasis in the development and improvement of the agricultural experiment stations because it is essential for proper distribution of irrigation water and disposal of excess surface water during the monsoon period, as well as for general good farming and tillage practices.

During the year primary consideration has been given to development of the experiment station farms at the U.P. Agricultural University, Pantnagar; the Punjab Agricultural College, Ludhiana; and the IARI. Emphasis on the two state agricultural universities stems from the integration of the maize improvement programs into their experiment stations. This move to associate the maize scheme with the research functions of these universities will have mutually beneficial results. The attention to land shaping and drainage at IARI derives from the key role played by this institution in the cooperative agricultural research and education program.

At the U.P. Agricultural University, 500 acres of land have been assigned to the agricultural experiment station. The 60 acres of this area which have been allocated to the maize scheme have been leveled and drainage ditches are under construction. A detailed land survey has been made of the remaining 440 acres to assist in the leveling of the land for irrigation and drainage purposes. This mapping was done by staff of the College of Agricultural Engineering at the university. The Rockefeller Foundation is collaborating and assisting in the developing, equipping, and operation of this station, and a special grant has been made to help take care of machinery acquisitions and operations.

At the experiment station of the Punjab Agricultural University, to which the maize substation at Naraingarh has been transferred, 80 acres have been leveled, drained, and put in shape for distributing irrigation water, and are in excellent condition for intensive research plots. Twenty acres of this area will be used for the maize improvement program. Plans are being made to assist in the development of 300 acres recently acquired to enlarge the experiment station area.

At the IARI serious difficulty has been encountered during the past two kharif seasons, with considerable loss of research data, because of insufficient surface drainage from the research fields. Several meetings have been held with representatives of the Agricultural Engineering and Agronomy staff at IARI to make plans for improving the drainage situation. Funds of Rs. 140,000 have been sanctioned by the Ministry of Food and Agriculture to support the drainage operation. A detailed land survey has been made by the staff of the Agricultural Engineering Division, and operations to level and drain this area have been initiated.

In addition to the work at these three locations, the main station at Srinagar, Kashmir, has been improved and shaped, and the entire tract of 50 acres is now ready for utilization.

Plans are being developed for mechanizing the farm operations within the Botany Division at the IARI; these include study of the organization of the operations, as well as of power and implement needs. The storeroom in the Botany Division area, which is used for replacement parts and supplies for the cereal research laboratory, is being enlarged. In the seed processing building in the same area, humidity and temperature controlled storage facilities needed for the sorghum and millet seed collections have been designed and are under construction. Consideration is also being given to more adequate vehicle and farm equipment maintenance facilities in this area.

Land leveling at the U.P. Agricultural University experiment station.

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A field of corn grown from improved seed, El Salvador.

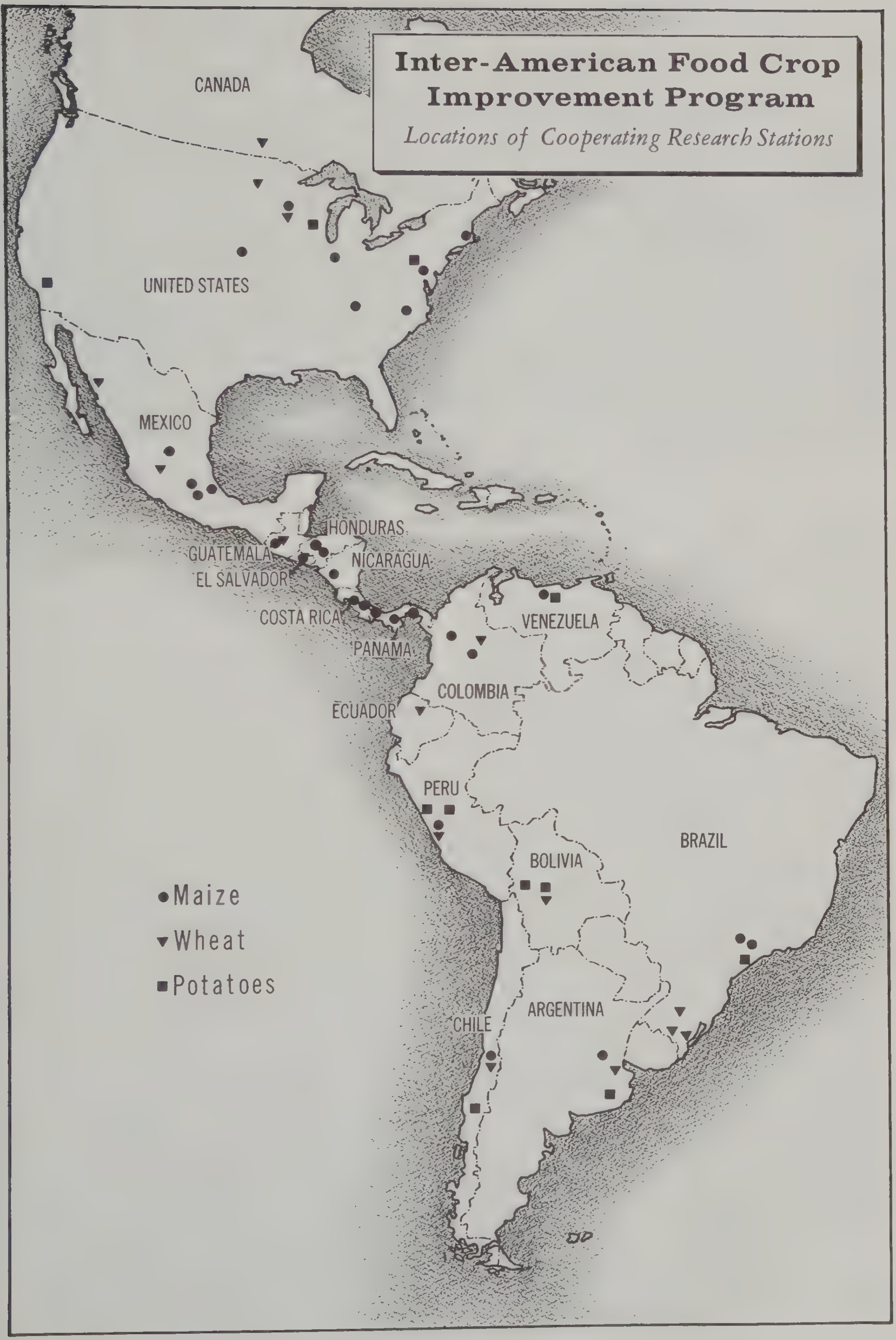
Introduction

The Inter-American Food Crop Improvement Program is dedicated to a more universal improvement in the efficiency of production of three of America's most important food crops—maize, wheat, and the potato. Two of these food plants are native to the Western Hemisphere and the third is native to the Near East. In all three the variation is enormous, and the possibility of developing cultivated varieties much superior to those now available in each of the many different ecological areas in which these crops are grown is extremely great. One of the principal objectives of this program is to promote the more complete exploitation of this vast range of germ plasm in the development of more productive varieties and to stimulate greater and more efficient production of food through a wider use of such varieties under more adequate conditions of soil fertility and field culture, especially in Latin America.

In Latin America, the program is being developed on a regional basis as follows: (1) Middle America, consisting of Mexico, Central America, and the Caribbean; (2) Andean Zone, consisting of Venezuela, Colombia, Ecuador, Peru, and Bolivia; (3) Southern Temperate Zone, including Chile, Argentina, Uruguay, southern Brazil, and Paraguay; and (4) tropical Brazil. In each region a special effort is being made to aid in the further development of local research programs and to stimulate cooperation among the scientists in their attempt to produce more and better food. Both intra- and interregional cooperative research projects are being developed. A free interchange of materials and information is being promoted throughout the Western Hemisphere. The results of research and materials obtained in the Mexican, Colombian, and Chilean Agricultural Programs are being more rapidly extended to other countries with immediate real benefit. These programs of The Rockefeller Foundation will continue to be the backbone of the Inter-American Program as centers for more basic research and in the training of personnel.

The main axis at present is in Mexico, where the program is collaborating with the Mexican Ministry of Agriculture in the development of an integrated center for research, education, and extension in agriculture. Special emphasis is being given to the promotion of certain cooperative basic research projects which will be of benefit not only to Mexico but to all of the Americas as well. Some of these projects are in cooperation with leading research institutions in the United States.

Training facilities are being expanded at the National School of Agriculture at Chapingo, and a more concentrated effort is being made for the training of local and foreign scientists in theory and practice, to form the basic core for new crop improvement projects throughout Latin America, or for the more efficient operation of those already in existence.


Inter-American Food Crop Improvement Program
Locations of Cooperating Research Stations
CANADA
UNITED STATES
MEXICO
HONDURAS
GUATEMALA
NICARAGUA
EL SALVADOR
COSTA RICA
PANAMA
VENEZUELA
COLOMBIA
ECUADOR
PERU
BOLIVIA
BRAZIL
CHILE
ARGENTINA
● Maize
▼ Wheat
■ Potatoes

Evaluating different varieties of maize in Central America.

Maize

During the past year, considerable effort was again devoted to the development of a basic research and training center at Chapingo, Mexico, in collaboration with the Graduate School and the National Institute of Agriculture Research (INIA), to serve as the main axis for the Inter-American Program. Dr. William Hatheway was transferred from the Colombian Agricultural Program to Chapingo to help with the development of the research and teaching programs there. Dr. Mario Gutiérrez G., Geneticist of the Inter-American Institute of Agricultural Sciences, spent most of last year in Mexico participating in this program. Drs. H. F. Robinson and Warren Hanson of the Department of Genetics, North Carolina State College, visited Mexico and assisted with the planning of basic research projects. Dr. John H. Lonnquist also visited Mexico last year and his ideas and suggestions were very valuable in the further development of the more basic research programs. Dr. E. C. Stakman's advice and counsel in the development of the teaching programs and research on maize diseases at Chapingo were most fruitful.

Research Sponsored in Mexico

As in previous years, the research sponsored in Mexico was promoted through special projects in cooperation with the National School of Agriculture at Chapingo, INIA with its several research centers in different areas of Mexico, and with the National Seed Production Agency at Tepalcingo, Morelos.

The cooperative research being conducted at Chapingo is closely tied in with graduate training. Many of the graduate students in genetics and plant breeding are participating in certain phases of the research and developing theses in partial fulfilment of the requirements for the Master's degree.

Several of the professors are carrying on special projects which they hope to present as theses in partial fulfilment of requirements for the Ph.D. degree at U.S. institutions.

Much of the research under way in Mexico involves the further identification, classification, and evaluation of the different germ plasm complexes in the Mexican regional bank. Also in progress is more fundamental work on interracial crosses and the nature and magnitude of genetic variability in certain populations which show considerable promise as basic breeding material in the further improvement of maize. More detail on projects in which significant data were obtained last year, is given below.

GERM PLASM BANK

The more than 5,000 collections in the Mexican germ plasm bank from Mexico, Central America, Panama, and the Caribbean countries have now been fairly accurately classified according to variety and race. The numbers of individual varieties and germ plasm pools (varietal composites) presently stored in the bank are as follows:

Country	*No. of composites*	*No. of individual collections*
Mexico	374	927
Central America	232	494
Caribbean countries	64	52
Total	670	1,473

In order to reduce the number of composites to be maintained still further, racial composites are being formed. In general, the bank is in good condition, with an ample supply of seed of each of the various entities in storage for special studies or breeding work.

COMBINING ABILITY OF MEXICAN RACES

Last year over 500 varieties of maize, representing all the races in Mexico except those commonly found above 2,000 m. elevation, were evaluated in crosses with a variety of the race Pepitilla. The results revealed considerable differences in combining ability among the different races and among varieties of a given race. Certain varieties of Tuxpeño, especially those prevalent along the Pacific Coast of Mexico, were definitely better than others. Likewise, certain varieties of Tabloncillo, Maíz Dulce, Reventador, etc. were definitely superior to others of the same races. This indicates the need for a rather thorough evaluation of the range of varieties within each race, in order to isolate those that might be most useful in future breeding programs.

It is now fairly well established that the races Tuxpeño and Celaya will be extremely valuable for the further improvement of maize in the tropics, and perhaps elsewhere. There is, however, quite a range of different varieties within these two races in Mexico, and it is not now known which of these varieties might be most useful. In an attempt to isolate the better types, a large number of varieties of both Tuxpeño and Celaya have been crossed with another variety of each race and with a variety of Chalqueño and of Salvadoreño. The purpose in using four races for this evaluation is to determine whether varieties that are good with one race are also good with another, or whether certain varieties yield well only in combination with a specific race. Seed of some of these crosses is being prepared for planting.

EVALUATION OF MATERIAL IN MEXICAN BANK FOR SPECIFIC CHARACTERS

Data are now available from the studies of stalk strength in the different races of maize initiated last year in collaboration with Dr. D. L. Thompson and the Field Crops Department of North Carolina State College. In this study, 561 varieties were tested representing the range of variation of maize in Mexico below 2,000 m. elevation. The crushing pressure for all varieties tested ranged from 100 to 1,890 lbs., with a mean of 461 lbs. Rind thickness ranged from 0.590 to 2.153 mm., with a mean of 1.309 mm. Varieties of the races Tuxpeño, Comiteco, and Puebla Grueso on the average had the strongest stalks and are probably the best source of stalk strength in breeding programs. Races generally showing little resistance to crushing pressure were Nal-Tel, Harinoso de Ocho, Dulce, Reventador, Tabloncillo, Pepitilla, and Cónico Norteño. Plants of these races are generally thin-stemmed and tiller rather freely. Some, however, are not especially susceptible to lodging in their native habitat. Fifty-nine of the 561 varieties (the tall, vigorous growing types) were selected as types meriting additional study as sources of fiber. The more detailed results of this study are being prepared for publication by Dr. Thompson.

At the Mexican germ plasm bank, Chapingo, seed is stored in jars at 8% moisture in a room maintained at 0°C. and 35% relative humidity.

HETEROSIS IN INTERRACIAL CROSSES

The first yield test of the 300 possible crosses among 25 Mexican races, along with their parents, has just been harvested. This test was conducted in a neutral environment, where all races are fairly well adapted. Results have not yet been analyzed. The 300 crosses have been or are being planted again this year in different environments. F_2 seed of each racial cross is also available now.

CHROMOSOME KNOB MORPHOLOGY

The chromosome knob morphology studies on the races of maize from Panama, Costa Rica, Nicaragua, Honduras, and El Salvador have been completed. As in some of the previous studies, it was found that different races tend to have different knob complexes and that these complexes are very useful in determining origin and relationships among the races. The number of knobs in the different collections examined ranged from 6 to 14.4. Most of the collections in Honduras were high in knob number, with an average of 12 to 13. In Costa Rica and Panama there was a correlation between low knob number and high altitude. The percentage of abnormal ten chromosomes seemed to be higher in varieties with a higher knob volume, whereas those with a lower knob volume tended to have a higher percentage of B-type chromosomes.

Knob morphology of the Caribbean collections is presently being studied. These studies will be completed this year, and the data obtained from the Central American and Caribbean areas will be analyzed more fully and prepared for publication.

SURVEY OF HELMINTHOSPORIUM SPECIES

This survey was made by Dr. R. R. Nelson, USDA, and Dr. Antonio Rodríguez of INIA. From the material collected, *Helminthosporium turcicum* has thus far been isolated from at least eight genera, including corn *Tripsacum*, teosinte, *Bermuda*, *Echinochloa*, *Paspalum*, *Sorghum*, and *Panicum*. Species of *Helminthosporium* other than *H. turcicum* have been obtained from one or more species in at least 35 genera of grasses. The range in morphology of the spores from the different isolates was fantastic.

CORN RUST SURVEY

This survey was made by Dr. Eugenio Schieber of Guatemala and Dr. Antonio Rodríguez. Rust was collected in all cornfields visited at different altitudes. It was found to be severe in only a few cases. *Puccinia sorghi* Schw. was found all over the Central Mesa at altitudes above 2,000 m. *P. polysora* Underwood was found at the lower altitudes from Orizaba to the coast of Veracruz, but also at an altitude of about 1,700 m. near Celaya, Guanajuato.

RESEARCH IN CENTRAL AMERICA

In addition to the breeding work in Central America, extensive fertilizer tests were promoted throughout the area this past year, which clearly pointed out the need for nitrogen and phosphorus. In Guatemala, an effort was made to classify further the high altitude Guatemalan collections stored in the Mexican regional maize bank. In Honduras, an excellent breeding program is getting under way in collaboration with the local Ministry of Agriculture and STICA; major emphasis is being placed on the development of improved, open-pollinated varieties through mass selection in a special mixture of different germ plasm complexes adapted to Honduras.

The office of the coordinator of the Central American program was transferred to Nicaragua, where much of the more basic work for the area will be concentrated in the future. Excellent cooperative working relations have been established with the agricultural research workers in Nicaragua.

In Panama, the maize work during the past year was concerned primarily with the production and distribution of a yellow intervarietal cross, Cuba 40 × Hawaii 5, which had a good record in the Central American cooperative yield tests. Also, certain yellow composites were made to serve as basic populations for further improvement through mass or recurrent selection.

RESEARCH IN SOUTH AMERICA

The maize project director spent some time in Venezuela during the past year, assisting in the development of plans for a maize improvement program to satisfy the ever-increasing demands for this grain within the country. The program is to be a cooperative one between the Ministry of Agriculture and the Mendoza Foundation and will involve improvement of varieties and also of the soil as well as multiplication and distribution of improved seed.

In August, 1961, the director met Dr. H. F. Robinson of North Carolina State College in Bogotá, Colombia, and traveled with him to Ecuador, Peru, Brazil, Argentina, and Chile to aid in the further development of the maize improvement programs in these countries.

In Colombia, the excellent work under way on racial crosses, inbreeding effects, and the nature and magnitude of genetic variability in adapted populations, was reviewed.

In Ecuador, where a maize program is just getting started, considerable time was spent with Professor Guillermo Merino D. in working out plans for the future.

In Peru the major portion of the time was spent in designing studies which certain of the young maize breeders could present as theses in partial fulfilment of the requirements for the Ph.D. degree.

In Brazil, a brief review was made of the data obtained by Ing. Glauco Pinto Viégas during the past year in the State of São Paulo. These data from a study of all possible crosses among 12 varieties representing different races throughout the Americas, reveal rather clearly the material most useful in the further improvement of maize in Brazil. Of the 66 crosses tested at two locations, Azteca (yellow Tuxpeño from Mexico) × the local Cateto Flint was the highest yielding, and equaled the best double-cross hybrid (H-6999) developed to date for the region.

In Argentina, Ing. Juan Carlos Rossi has obtained very promising results with the crosses he made in Mexico between certain Caribbean varieties and the Corn Belt Dents (see following section on inter-American tests). Some of these yielded extremely well in Argentina, much better than the local double-cross hybrids, and have opened the way for new horizons in corn improvement in Argentina.

INTER-AMERICAN YIELD TESTS

The purpose of the inter-American yield tests is to identify those germ plasm complexes which might be most useful for the further improvement of maize in the Western Hemisphere. During the past year some very interesting data have been obtained.

UNIFORM TESTS OF DENTS × FLINTS

As described in last year's report, ten outstanding dent varieties have each been crossed with ten outstanding flint varieties, and the resulting 100 crosses tested at six locations in

Latin America: Tepalcingo (winter) and Cotaxtla (summer), Mexico; Nicaragua, Colombia, Peru, and Brazil.

The three dent varieties that gave the best over-all average performance in combination with each of the flint varieties were Mix. 1, a Tuxpeño from the southern coast of Guatemala; Mexican White Synthetic, developed in Piracicaba, Brazil, from a number of Tuxpeño varieties sent from Mexico; and Capitaine, a variety of Tuxpeño from northern Veracruz in Mexico. The first two were particularly outstanding in their performance at all locations.

The best of the flints in average performance was Diacol V-351 (Eto Blanco) of Colombia. The advanced progeny of the cross Nariño 330 × Peru 330, and Eto Amarillo, also of Colombia, did almost as well as V-351. As in the case of the dent varieties, the performance of these three at the different locations was surprisingly consistent.

Even more surprising, however, is the yield of some of these intervarietal crosses in comparison with the yield of the best local hybrids included in the test at each location. The five highest yielding intervarietal crosses in percentage of the hybrid at each location are given below:

Mexico (Winter)	%
H-502 (hybrid)	100
Cuba 28 × Nariño 330	103
Carmen × Diacol V-351	100
Mex. Wh. Syn. × Florida Fl. Syn.	97
Mix. 1 × Diacol V-351	95
Mex. Wh. Syn. × Diacol V-351	95
Mexico (Summer)	
H-503 (hybrid)	100
Capitaine × Am. Salvadoreño	105
Cuba 28 × Am. Salvadoreño	97
Cuba 28 × P.D.(MS)6	97
Mex. Wh. Syn. × Florida Fl. Syn.	96
Capitaine × Florida Fl. Syn.	95
Nicaragua	
H-503 (hybrid)	100
Mex. Wh. Syn. × Florida Fl. Syn.	114
Mex. Wh. Syn. × P.D.(MS)6	107
Cuba 28 × Florida Fl. Syn.	106
Mex. Wh. Syn. × Eto	100
Mex. Wh. Syn. × Diacol V-351	100

Colombia	%
Eto (synthetic)	100
Mex. Wh. Syn. × (Nariño 330 × Peru 330)	142
Capitaine × (Nariño 330 × Peru 330)	122
Cuba 28 × (Nariño 330 × Peru 330)	118
Mix. 1 × Diacol V-351	130
Mix. 1 × Eto	116
Peru	
PM 211 (hybrid)	100
Mex. Wh. Syn. × (Nariño 330 × Peru 330)	138
Mix. 1 × (Nariño 330 × Peru 330)	137
Capitaine × (Nariño 330 × Peru 330)	131
Capitaine × Diacol V-351	125
Mix. 1 × Eto	120
Brazil	
Paulista Dent (synthetic)	100
Mex. Wh. Syn. × (Nariño 330 × Peru 330)	142
Mix. 1 × (Nariño 330 × Peru 330)	137
Mix. 1 × Eto	137
Mix. 1 × Am. Salvadoreño	137
Diacol V-101 × Cateto	136

Except in the Mexico (summer) tests, crosses of Tuxpeño and Eto either white or yellow, were among the five highest yielding crosses at each location. The excellent combinability of these two germ plasm complexes is further substantiated by tests in Central America (1961) where the cross Sicarigua (Tuxpeño Venezuela) × Eto Blanco yielded 106% of H-507, one of the best Tuxpeño hybrids adapted to the lowlands of Central America, as an average of 11 tests in different locations.

CARIBBEAN COLLECTIONS

Crosses with Azteca

In order to obtain information on which varieties or races in the Caribbean might be most useful in the further improvement of maize in the tropics, 45 varieties were picked more or less at random from the over 300 Caribbean collections of dents, flints, and intermediate types in the Mexican bank and crossed to the variety Azteca, developed in Brazil from Mexican yellow Tuxpeño varieties. These crosses were tested in five locations, two in Mexico and one each in Peru, Brazil, and Argentina.

Cuban Flint varieties are extremely useful in the improvement of Dent varieties throughout the tropics and elsewhere.

With one exception, the highest yielding collections in combination with Azteca were varieties of Coastal Tropical Flint. Collections from Antigua and San Vicente represent some of the purest forms of this race. In Mexico and Peru, crosses between varieties of this race and Azteca yielded more than the local hybrids included in the tests.

Crosses with U.S. Corn Belt Varieties

A number of Caribbean collections selected at random from each country were topcrossed with each of the single crosses involved in the hybrid A.E.S. 801, (WF9 × B7) and (B10 × B14), and a Corn Belt composite made up by Dr. William Brown of the Pioneer Hibred Corn Company. Because of an insufficient number of plants of any one Caribbean collection in the field at the time crosses were made, different collections of a given race were used in making the crosses with the three varieties mentioned. The resulting crosses were tested at six locations: Nebraska, Indiana, North Carolina, and Mississippi in the United States; Argentina, and Mexico.

Among the crosses with WF9 × B7, the yield of the best topcross at each location was equal to or exceeded that of A.E.S. 801 in every case, and at four locations was equal to or higher than that of the best adapted local hybrid. These topcrosses involved the Caribbean collections Antigua 2 D, Florida Flint Synthetic, Trinidad 8, Antigua 7 D, and Puerto Rico 24 D. When all the topcrosses are ranked according to average yield at all locations, it is evident that the Coastal Tropical Flints or Cuban Flints yielded higher in combination with WF9 × B7 than Tusón (West Indian dent and semi-dent) or Tuxpeño, the white tropical dent of Mexico.

Among the Caribbean collections crossed with B10 × B14, the best over-all score—even better than that of the best local hybrids—was made by Puerto Rico 24 D, a variety of the race St. Croix, which Dr. Brown believes may have been derived from Hickory King of the southeastern United States or Olotillo of

Mexico. With the exception of this variety and Puerto Rico 2 D, a dent similar to 24 D, the best-yielding topcrosses with B10 × B14 were those involving varieties of Cuban and Coastal Tropical Flints.

In the crosses with the Corn Belt composite (CBC), that involving Cuba 16 was among the highest yielding at each location. Cuba 16 is classified as Cuban Flint-Dent. Another Cuban Flint-Dent variety that performed consistently well in crosses with CBC was P.D.(MS)6. The best of the Tusón varieties (West Indian dent) was Trinidad 4, which yielded well at all locations in crosses with CBC.

MEXICAN RACES × CORN BELT SINGLE CROSSES

A typical variety of each of a number of different Mexican races of maize was crossed with each of the single crosses involved in A.E.S. 801, and the resulting crosses were tested in Nebraska, Indiana, North Carolina, Mississippi, and Mexico.

The races of western Mexico (Harinoso de Ocho, Zapalote Grande, Vandeño, Reventador, and Tabloncillo) were generally superior to the others in crosses with WF9 × B7 and B10 × B14. Harinoso de Ocho, the prevalent race in northwestern Mexico, was especially outstanding; the average yield of crosses involving this race equaled that of A.E.S. 801. None of the crosses, however, yielded as well as some of the crosses between the Caribbean collections and these Corn Belt single crosses.

A preliminary evaluation of these same Mexican races made in North Carolina, based on performance in combination with other Mexican races, coincides very closely with the classification based on performance in combination with the Corn Belt single crosses. Of the 25 tested in North Carolina, the seven best in descending order of rank were: Harinoso de Ocho, Zapalote Grande, Zapalote Chico, Chapalote, Reventador, Vandeño, and Nal-Tel. These data again point out the superiority of the races prevalent in western Mexico over others in Mexico when evaluated at more northern latitudes.

GENERAL CONCLUSIONS

(1) Varieties of the race Tuxpeño in Mexico and of the Cuban and Coastal Tropical Flints in the Caribbean represent the most outstanding germ plasm resources yet discovered for the further improvement of maize throughout the tropics. Furthermore, it appears that this germ plasm can be useful for the improvement of maize in the temperate zones. Certain Tuxpeño varieties have been found to be more productive than any other variety in the lowland tropical areas around the world. This germ plasm, as it moved north many years ago, came in contact and hybridized with some of the northern flints to produce the world's most productive maize for temperate zones, namely, the Corn Belt Dents. Where the northern flints came from has not been definitely established, but it is fairly certain that the basic germ plasm contributing to their development came from the tropics.

Tuxpeño also moved out into the Caribbean, where it met the Coastal Tropical Flints to produce the very productive West Indian semi-dent varieties, which have now become the prevalent types throughout the Caribbean area. Both the Corn Belt Dents and Caribbean Dents came into being largely through accidental interhybridization of the Tuxpeño and Flint complexes. On the basis of the above argument, it appears that the modern plant breeder in the United States might find it very profitable to utilize one or both of the original parents in the further improvement of the Corn Belt Dent. Likewise, the plant breeder in the tropical or semitropical areas of the world might obtain better results in the improvement of some of the modern, relatively productive varieties of Dent and semi-Dent by utilizing the basic components of these varieties in his breeding programs, rather than the varieties themselves. This might be especially useful in the production of better hybrids.

(2) It is very evident that yields of present hybrids in tropical or semitropical Latin America may be markedly improved through a program of reciprocal recurrent selection between two populations, one consisting of

varieties of Tuxpeño and the other of Cuban or Coastal Tropical Flints.

(3) According to the present data, the most outstanding materials for the immediate development of superior yellow hybrids in the tropics through a program of reciprocal recurrent selection are yellow Tuxpeño (Azteca and the Mexican yellow Composite 48 or a mixture of both) as population A, and the Coastal Tropical Flints from San Vicente and Antigua as population B. Other varieties such as Eto Amarillo, Cateto in Brazil, and some of the best of the Cuban Flints could also be used as population B.

In a separate experiment in the State of São Paulo, Brazil, apart from the uniform inter-American tests, the intervarietal cross Azteca × Cateto yielded more than any other intervarietal cross as an average of two years' data and was equal in yield to the best Brazilian hybrid H-6999 developed at Campinas. However, as is evident from the inter-American tests, Cateto does not maintain this good performance outside its native habitat.

(4) It appears that the hybrid A.E.S. 801 can be greatly improved for the Corn Belt of the United States through a reciprocal recurrent selection program between two populations made up as follows: (a) advanced generation progeny of (WF9 × B7) × Puerto Rico 24 D, or advanced generation progeny of the first backcross to WF9 × B7; and (b) advanced generation progeny of (B10 × B14) × varieties of Cuban and Coastal Tropical Flint, or advanced generation progeny of the first backcross to B10 × B14 resulting in about 25% of the exotic germ plasm.

(5) The best exotic material for the immediate further improvement of the Corn Belt hybrids appears to be varieties of Cuban Flint and Coastal Tropical Flint.

(6) The purest Coastal Tropical Flint varieties in the Mexican bank are those from Antigua and San Vicente. These are earlier in maturity than most varieties of Tuxpeño and Tusón (West Indian Dent). They are also shorter in plant and ear height than most Tuxpeño varieties.

(7) The West Indian Dent varieties in their purest forms are probably largely Tuxpeño with a certain amount of introgression of the Caribbean flints. In general, they are more productive than the flints found in the same area. They may be very useful, like Tuxpeño, in reciprocal recurrent selection programs with the Caribbean flints throughout the tropics.

(8) In Northern India some of the U.S. dent varieties are fairly productive; the Caribbean flints are also fairly well adapted to this area. In view of this and the good combinability of U.S. dents with Caribbean flints, a reciprocal recurrent selection program between these two germ plasm complexes should be strikingly fruitful.

(9) A program of reciprocal recurrent selection between the dents (Tuxpeño and Caribbean) and the Cuban—Coastal Tropical Flint complexes should pay extremely large dividends in Southeast Asia.

(10) Most of the better varieties in the Caribbean or other areas of the lowland tropics are semi-dent or semi-flint, obviously resulting from the intercrossing of Dent × Flint. It is very likely that these varieties might be further improved through mass and certain special forms of recurrent selection. However, rather than using the semi-dent varieties already in existence as a base population, perhaps greater progress could be made with populations reconstituted from the intercrossing of the best dents and flints. Further studies on these methods are needed.

(11) The Coastal Tropical Flints are the predominating types of maize in eastern and northeastern Brazil and in the Guianas. Very few collections from this area are available in the Brazilian bank. Judging from the data obtained in the inter-American tests, this area should be more thoroughly sampled and collections fully evaluated.

Formation of Composites as Basic Breeding Materials

Various composites have been made up for use as basic breeding materials in different areas of the tropics. Some of these will provide excellent material for mass or recurrent selection programs, while others might best be used in reciprocal recurrent selection programs. Composites available, and a brief explanation of their origin, are given below.

(1) Flint-Dent Composite, yellow. (Cuba 40-Hawaii 5-SLP 104.) These three varieties (Cuban Flint, Flint-Dent, and Tuxpeño Dent, respectively) have given excellent yields in every possible combination. A composite was made of these three varieties by mixing equal quantities of seed of each of the three possible crosses among them, planting it in an isolated block, and allowing the resulting population to open-pollinate. It has now gone through two generations of random pollination. Where improved yellow varieties are needed, this population should form an excellent base for mass or recurrent selection.

(2) Flint-Dent Composite (yellow). This composite was made by mixing seed of each of ten high-yielding intervarietal crosses of yellow flints and dents and allowing open pollination to occur in isolation. It has a somewhat broader base than Composite 1.

(3) Caribbean Composite (yellow flint-dent). This is a very wide base composite made up by mixing seed of the more productive collections of the Caribbean races (Cuban Flints, Coastal Tropical Flints, Semi-Dents, and Dents) plus the tropical Semi-Dents of Costa Rica and Panama; to this were added the yellow Tuxpeños of Mexico and Corn Belt Dent, making up about 20% of the mixture. This mixture is now in the third generation of open pollination. It, like the other two, should make excellent material for mass and recurrent selection programs.

(4) Tuxpeño-Caribbean Composite (yellow and white flint-dent mixture). This population was formed by mixing equal quantities of seed of the highest yielding flint-dent intervarietal crosses in the inter-American tests. It contains four Tuxpeños (Mix. 1, Mex. Wh. Syn., Capitaine, and Diacol V-101) and five Flints (Eto, Venezuela 1, Nariño 330 × Peru 330, P.D.(MS)6, and Florida Flint Syn.). The mixture has been propagated by open pollination in isolation.

(5) Tuxpeño-Salvadoreño Composite (white dent and semi-dent). This originated by mixing equal quantities of seed of the high-yielding Tuxpeño × Salvadoreño intervarietal crosses. The resulting population was allowed to open-pollinate in isolation.

(6) Caribbean - Salvadoreño Composite (white and yellow flint-dent mixture). This composite was made up by mixing seed of high-yielding intervarietal crosses of Caribbean Flints and Semi-Dents with a Salvadoreño Composite, and open-pollinated in isolation.

(7) Tuxpeño-Caribbean-Salvadoreño Composite (yellow and white). This composite was made by intercrossing of Composites 4, 5, and 6 above. According to present data, Tuxpeño varieties in general manifest considerable heterosis with selected varieties from the Caribbean and with varieties of the Salvadoreño race. Selected varieties of the Caribbean have also been excellent yielders in combination with varieties of Salvadoreño. This wide-base composite should be especially useful for the development of high-yielding varieties through mass or recurrent selection in Central America.

(8) Tuxpeño Composite (white dent). This composite was formed by intercrossing the most outstanding collections of the race Tuxpeño from different areas of Mexico.

(9) Caribbean Dent Composite (yellow). Primarily a mixture of the West Indian dents and semi-dents.

(10) Cuban Flint Composite (yellow). A mixture made from the intercrossing of Eto, Peru 330 × Nariño 330, P.D.(MS)6, Am. Salvadoreño, and Florida Flint Synthetic.

(11) Coastal Tropical Flint Composite. A composite made from intercrossing of the purest Coastal Tropical Flint collections, primarily from San Vicente and Antigua.

SEED SHIPMENTS

As in previous years, a great many requests for maize seed were received from different parts of the world. Countries and territories to which seed was sent are as follows:

Central America: All countries.

South America: Argentina, Bolivia, Brazil, British Guiana, Chile, Colombia, Ecuador, Peru, and Venezuela.

Caribbean: Dominican Republic, Haiti, and Jamaica.

United States: California, Colorado, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, Nebraska, New York, North Carolina, Ohio, and Wisconsin.

Africa: Angola, Ivory Coast, Kenya, Liberia, Malagasy Republic, Mali, and Nigeria.

Others: Austria, England, France, India, Nepal, Philippines, Thailand, and United Arab Republic.

TEMPORARY SCIENTIFIC AIDES

Mario Gutiérrez G., Ph.D., Geneticist, Inter-American Institute of Agricultural Sciences; Special Research Aide in maize genetics, also aiding in graduate teaching at Chapingo; November 20, 1961—December 31, 1962.

A. E. Longley, Ph.D., Cytogeneticist, Agricultural Research Service, U.S.D.A., retired; Special Temporary Research Aide in the cytogenetics of maize, Graduate School, Chapingo; May 1—October 31, 1962. This year Dr. Longley is concentrating his research on the chromosome morphology of the races of maize in the Caribbean and in Guatemala.

R. R. Nelson, Ph.D., Maize Pathologist, Agricultural Research Service, U.S.D.A., North Carolina State College; survey of variation in *Helminthosporium* species attacking maize in the tropics; September 10–30, 1961.

Eugenio Schieber, Ph.D., Phytopathologist, Plant and Animal Research Institute, Guatemala; survey of *Puccinia* sp. (maize rust) in Mexico; August 6–20, 1961.

GRADUATE ASSISTANTS

K. R. Chopra, Technical Assistant, Coordinated Maize Breeding Scheme, New Delhi, India; February 22—September 10, 1962.

Ignacio Méndez R., Pasante, National School of Agriculture, Chapingo; January 1—December 31, 1962.

Juan Cisneros D., Pasante, National School of Agriculture, Chapingo; January 1—December 31, 1962.

Francisco Cartujano R., Pasante, National School of Agriculture, Chapingo; January 1—December 31, 1962.

VISITORS

E. R. H. Martin, Agronomist, Ministry of Agriculture and Lands, Hope, Kingston, Jamaica; March 12–24, 1962. His primary interest in visiting Mexico was to get acquainted with new breeding materials and how they might be used for the further improvement of maize in Jamaica.

H. F. Robinson, Ph.D., Head, Genetics Department, North Carolina State College, Raleigh; September 10–16, 1961.

John H. Lonnquist, Ph.D., Professor of Agronomy, University of Nebraska, Lincoln; December 18–22, 1961.

Warren Hanson, Ph.D., Professor of Genetics, North Carolina State College, Raleigh; April 2–16, 1962.

FAO scholars from Pakistan, Iraq, and Syria crossing wheats in the experimental plots at CIANO, Mexico.

Wheat

The Inter-American Wheat Improvement Project developed out of the cooperative wheat improvement work in Mexico and a number of its activities continue to be collaborative with the National Institute of Agricultural Research (INIA) and the National School of Agriculture at Chapingo. The project is international in scope, however, and involves the training of young scientists from Latin America and the Near and Middle East as well as cooperative yield tests with wheat breeders in many parts of the world.

Training of Young Scientists

In the past three years, the director of the wheat project has been able to give increasing attention to the training of young scientific personnel from countries in Latin America. Moreover, in this same interval training activities have been expanded to include young scientists from the Near and Middle East. This training program is a joint undertaking of the Food and Agriculture Organization of the United Nations, the Mexican Ministry of Agriculture, and The Rockefeller Foundation. During the period covered by this report, the first group of seven FAO scholars finished their training and returned to their respective countries. A second FAO group of six scholars from the United Arab Republic, Iran, Iraq, Jordan, Pakistan, and Syria arrived in Mexico on February 14, 1962, and will remain through October. In addition, during the report period one scholar from Argentina and another from Guatemala received training, and considerable emphasis was given to assisting in providing a more thorough training for young Mexican personnel.

TYPE OF TRAINING

The type of training provided for the scholars now in Mexico can be summarized in the following way:

Field seminars: One day of each week during the field season is dedicated to informal seminars conducted in the experimental plots. These seminars include not only the FAO and Latin American scholars but also, when time permits, most of the younger Mexican scientists. The seminars cover all principles involved in wheat improvement programs and in program planning. Emphasis is given to the need for flexibility in program orientation, depending upon the requirements and stage of evolution of research programs of the country under consideration. The director of the wheat project has been assisted in these seminars by Dr. Jacobo Ortega.

Field plot training: During the course of the scholarship period in Mexico, all trainees receive a breadth of experience in field plot training. This includes taking agronomic and disease data, learning and applying techniques used in crossing of wheat varieties, assisting in the selection of individual plants in segregating populations, active participation in harvesting and threshing of the yield plots and in weighing and determining test weight of grain from such plots, and planting and handling of summer nurseries for the control of weeds.

Summarization of data: Considerable time is spent by each trainee in becoming thoroughly familiar with the summarization and statistical analysis of yield data.

Experience in rust research techniques: During the summer season, the trainees spend at least one month in the greenhouse and in the experimental plots becoming familiar with the stem-rust organism, the techniques used in the identification of races of this organism, and the methods used for the screening of experimental wheat lines for rust resistance in the seedling stage. They also acquire experience with the techniques used for creating artificial epidemics and in the evaluation of rust resistance of individual lines in the adult stage.

Experience in wheat quality evaluations: During a part of the summer period approximately three weeks are spent by each trainee in the Farinology Laboratory to acquire experience in the use of early generation tests, such as Micro-Pelshenke sedimentation and mixogram, and advanced testing including the techniques used in milling and baking of the most promising lines and varieties. The trainees also become familiar with the basic chemical determinations, i.e., protein, ash, moisture, etc.

Formal conferences: During the course of the training period a series of lectures is given by Drs. Ignacio Narváez, Jacobo Ortega, Alfredo Campos T., and Reggie J. Laird and the wheat project director, covering both the theoretical and applied considerations affecting wheat production from the standpoint of the disciplines of plant pathology, agronomy, soil science, plant breeding, and cereal chemistry.

Throughout the training program emphasis is on "learning by doing" or by active participation in all the activities described above. Learning by observing and non-participation are not tolerated.

RESULTS OF FIRST TRAINING PROGRAM

The first group of FAO trainees returned to their respective countries in October of last year after acquiring a lot of practical information relating to wheat improvement. The progress that these young men made while in Mexico was formidable, from many points of view. Everyone associated with the program was pleased with the over-all results obtained.

The training program during this current year appears to be developing even better, since more emphasis is being given to the theoretical side of the training, without de-emphasis of the practical aspects which must always be of prime importance for young people returning to countries where they will be involved in the organization of new wheat improvement programs, or in assisting in the development of programs still in their infancy.

INTERNATIONAL COOPERATIVE RESEARCH PROJECTS

INTER-AMERICAN WHEAT YIELD NURSERY

This cooperative undertaking was initiated two years ago. The first nursery results are now summarized for publication and the data are beginning to arrive for compilation for the second nursery. A third nursery will be prepared for distribution to cooperators within the next month.

NEAR EAST–AMERICAN WHEAT YIELD NURSERY

Twenty-one sets of this nursery were sent out last year to cooperators largely in the Near and Middle East, and also to collaborators in Colombia and Mexico. This nursery includes the principal Near East varieties of spring wheat as well as several Colombian, Australian, and Mexican varieties, all of which are relatively insensitive to day-length.

Results of these tests will be compiled by FAO in Rome.

INTERNATIONAL EXCHANGE OF GENETIC MATERIALS

In cooperation with INIA, the Inter-American Wheat Improvement Project furnishes genetic materials to wheat breeders around the world. These materials include varieties which will be used primarily as parents. In other cases, remnant F_2 seed, no longer needed in Mexico, is made available to countries where there are technical people with sufficient experience and program organization to utilize it with some hope of success. Promising advanced generation lines from the INIA breeding program have also been sent in small quantities to other countries for testing; a number of commercial varieties have been selected from such materials and are being used commercially by collaborating countries.

In an entirely different approach, the inter-American wheat project facilitates the introduction, testing, and evaluation in Mexico of wheats from many other countries to determine their possible use, either directly as varieties or indirectly as parental material for crosses, both in Mexico and elsewhere.

These exchanges of seed stocks are of prime importance to the improvement of wheat throughout the world, and help to prevent stagnation in breeding programs.

FAO SCHOLARS

The following scientists are visiting the Mexican Wheat Improvement Program on FAO scholarships awarded for the period February 14–October 30, 1962:

Anwar Alaka Iskander, Specialist and Assistant at the Experiment Station, Sulaimania, Iraq.

Nur Mohammed Chaudri, Assistant Investigator, Cereals Section, College of Agriculture, Lyallpur, West Pakistan.

Jamil Awad Quhaiwi, Official Assistant in Investigations, Department of Scientific Investigations, Ministry of Agriculture, Jordan.

Houshang Khazra, Assistant Plant Pathologist, Institute for the Improvement of Seed, Genetics and Cereal Station, Karaj, Iran.

Abdul Kerim Kouiedar, Head, Crop Section, Ministry of Agriculture, Damascus, Syria.

Abdul Salam Gomaa, Phytogeneticist, Department of Investigation in Wheat and Barley, Ministry of Agriculture, United Arab Republic.

ROCKEFELLER FOUNDATION SCHOLARS

Enrique René Ernié, Ing. Agr., Wheat Specialist, Experiment Station "Marcos Juarez," Córdova, Argentina; March 3, 1961–April 1, 1962.

Jorge Luis Juarez, Ing. Agr., National Livestock Institute, Quezaltenango, Guatemala; April 26–October 31, 1962.

VISITORS

E. R. Sears, Ph.D., Agricultural Research Service, U.S.D.A., University of Missouri, Columbia; August 10–21, 1961.

Ansell Anderson, Ph.D., Canada Department of Agriculture, Winnipeg; March 22–24, 1962.

Glenn Anderson, Ph.D., Plant Breeding Laboratory, Canada Department of Agriculture, Winnipeg; March 18–April 10, 1962.

H. Roald Lund, M.S., Department of Agriculture, North Dakota State University, Fargo; March 18–April 10, 1962.

Benjamín Quijandría, Ing. Agr., Assistant Director, Agricultural Research Service, Lima, Peru; August 11–15, 1961.

Eugene Hayden, Crop Quality Council, Minneapolis, Minnesota; March 17–21, 1962.

Vance Goodfellow, Crop Quality Council, Minneapolis, Minnesota; March 17–21, 1962.

Jean Lambert, Ph.D., Soybean and Barley Breeder, University of Minnesota, Minneapolis; March 10–22, 1962.

Potato seed production field in the Peruvian Andes.

Potatoes

During the first year of operation of the Inter-American Potato Improvement Project, emphasis was placed on three prime objectives: (1) the organization of potato research in Latin America on an international and regional basis; (2) the establishment of basic research projects of international importance in selected locations; and (3) the training of personnel for key positions in potato research in Latin American countries. These are long-term objectives, and perhaps can never be considered "completed." However, important progress can be reported in each of these phases of the project during the past year.

REGIONAL ORGANIZATION OF POTATO RESEARCH IN LATIN AMERICA

The regional organization of potato research in Latin America not only facilitates closer coordination of research effort within each region, but also provides for each region a research center at which support can be concentrated, thus making the maximum use of limited funds.

In most Latin American countries, as well as elsewhere, limited budgets put ceilings on research effort. Unfortunately, this has been particularly true in research on basic food crops, such as the potato. In order to maximize the contribution made by the research funds available, concentration of effort and collaboration on an international scale are needed.

During the course of two trips to Latin America in February-March and October-December, 1961, the director of the inter-American potato project planned with potato research leaders in 12 countries the coordination of potato research in Latin America on a regional basis. Four regions were established: (1) the Northern Region, composed of Mexico, Central America, and the Caribbean countries, with the center at Mexico City, and with Dr. Javier Cervantes, head of the potato research in INIA, as leader; (2) the Northern

Andean Region, composed of Venezuela, Colombia, and Ecuador, with the center at Bogotá, and with Dr. Lee Heidrick of the Colombian Agricultural Program as leader; (3) the Central Andean Region, composed of Peru and Bolivia, with the center in Peru at Lima and Huancayo, and with Ing. Carlos Ochoa, head of the Peruvian Potato Program, as leader; and (4) the Southern Region, composed of southern Brazil, Uruguay, Argentina, and Chile, and with Ing. Domingo Pasquale, head of the INTA Potato Research Station at Balcarce, as leader. The responsibility for coordinating potato research projects, both within and among the four regions, falls to the director of the Inter-American Potato Improvement Project.

These regional units of the Latin American potato research effort are designed to facilitate the interchange of materials and ideas within zones where production practices and problems tend to be common to the area. Emphasis here is given to cooperation between national potato research programs in the region, so as to avoid the inefficiencies of duplication of effort and unnecessary expenditures. Exchange of new selections and varieties, development of control measures for common insect and disease problems, and exchange of information on soil fertility problems, are examples of this type of cooperation that was developed in 1961.

Basic Research Projects In Latin America

The potential contribution of a coordinated potato research program in Latin America is a great one, not only because there are large areas in Latin America where the potato is a basic food and yields are distressingly low, but also because the native home of the potato—Latin America—is the best place to study and solve many important problems in world potato production.

By carefully selecting certain basic research problems of international importance, and scientifically exploiting unique Latin American locations where the solutions can best be sought, the Inter-American Potato Improvement Project can make an outstanding contribution.

MEXICO

Mexico, the regional center for the Northern Region of the project, has several important advantages as an international center for potato research. First, an excellent research group has been established in INIA, and provides the personnel around whom research projects can be built. Second, Mexico is one of the two gene centers of tuber-bearing *Solanum* species, and lends itself to research on these germ plasm sources better than any other region. Third, it is the place of origin of *Phytophthora infestans*, and work on this pathogen and the late-blight disease can be done better here than anywhere else in the world.

Its unique location in the endemic center of the late-blight pathogen makes Mexico an invaluable testing ground for resistant selections and varieties created in potato breeding programs in other parts of the world. Furthermore, new blight-resistant Mexican varieties have proven of great interest to other potato programs, either as direct introductions or as resistant germ plasm in the local breeding programs. International coordination of this cooperative research was an important function of the Inter-American Potato Improvement Project in 1961, and will continue to be in the future.

During the past decade, this international trend in potato research in Mexico has resulted in a broad program. Scientists in the following 45 countries have exchanged material with the Mexican program:

Canada, United States, Haiti, Jamaica, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Brazil, Argentina, Ecuador, Peru, Chile, Bolivia, Ireland, Scotland, England, France, Belgium, Holland, Denmark, Sweden, West Germany, East Germany, Soviet Union, Poland, Yugoslavia, Italy, Austria, Australia, New Zealand, Viet Nam, Indonesia, Japan, Egypt, Turkey, Syria, Pakistan, Afghanistan, India, Kenya, and South Africa.

The inter-American potato project is developing two basic research projects in Mexico, in collaboration with the potato research section of INIA.

(1) Basic research on the late-blight disease and its pathogen, *Phytophthora infestans.*

These studies include research on the genetics of the pathogen, the source of variability in pathogenicity, and the nature and prevalence of sexual compatibility groups. Ing. Jorge Galindo, now studying for the Ph.D. degree at the University of California, will return in early 1963 to resume local leadership of this project.

During 1961 a small greenhouse was put into operation at the Santa Elena Experiment Station at Toluca. This greenhouse has been an invaluable asset to the late-blight research program there, though it is still inadequate for the program's needs.

(2) Establishment of a germ plasm center for study of Mexican tuber-bearing *Solanum* species.

During the past 40 years Mexico has been visited by many collecting expeditions from a number of countries. From Mexico much native potato material has been taken for study and use in breeding programs in other countries. Strangely enough, Mexico has never participated in these expeditions, and until recently has not had a project to study the native species of *Solanum.* This project is being fostered in the Inter-American Potato Improvement Project, not only because Mexico and neighboring countries could profit directly thereby, but because Mexico is the logical place to establish a center for research on these locally prevalent species.

Initiated in 1961, this Mexican germ plasm project now consists of over 200 accessions (seeds, tubers, and herbarium specimens). Close research ties were established with the USDA—Wisconsin group at Sturgeon Bay, directed by Dr. Robert W. Hougas. Dr. Hougas himself visited the Peruvian, Colombian, and Mexican potato research programs in November and December, 1961, accompanied by the director of the inter-American potato project.

With the establishment of a germ plasm center, it is obvious that much more is involved than the gathering and maintenance of a number of collections. Research projects must be established that will provide meaning and progress in the program, and that will attract and merit support, both in personnel and in financing, by institutions interested in potato research in other parts of the world.

PERU

Two basic research projects are also being developed in Peru.

(1) Establishment of a germ plasm center for the collection and study of South American tuber-bearing *Solanum* species.

Peru is situated near the geographic center of the larger of the two gene-centers of tuber-bearing *Solanum* species. Though frequent collecting expeditions have passed through Peru to gather germ plasm material for breeding programs in Europe and North America, the rich native sources of *Solanum* germ plasm existent in Peru and neighboring countries are still only partially known and practically unexploited by potato breeders.

On the basis of the enthusiasm shown for this project by officials of the Peruvian Ministry of Agriculture, steps were taken in 1961 to establish the germ plasm bank of South American *Solanum* species, at Lima and Huancayo, in Peru. Fortunately, leadership for this project can be provided by Ing. Carlos Ochoa, an outstanding authority on *Solanum* species in this area, and leader of the Peruvian national potato research program. In the fall of 1961, Ing. Ochoa visited Mexico for one month, during which time the basis was laid for coordinating the germ plasm research projects in Peru and Mexico.

(2) Research on the golden nematode, *Heterodera rostochiensis.*

The golden nematode is of more importance in Europe than in the Western Hemisphere, though it is a limiting factor in potato production in certain areas in Peru. Furthermore, it has cost many millions of dollars to study, control, and eliminate this pathogen in small, restricted areas of the United States. Peru is the native home of this pathogen, and offers the best place in the world to study the pathogen and sources of resistance.

In 1961, a grant of approximately $100,000 of Public Law 480 funds was made to the Peruvian government to study the golden nematode. Studies on resistance and sources of resistance will be coordinated with the work of the germ plasm center in Peru, under the direction of Ing. Ochoa.

TRAINING OF POTATO RESEARCH PERSONNEL IN LATIN AMERICA

This is considered a vital phase of the program of the Inter-American Potato Improvement Project, and it gained some momentum during 1961.

In June, Ing. Jorge Christiansen, a young research scientist in the Peruvian potato program, began a year's training as a member of the Mexican potato research group of INIA.

Beginning in July, 1961, Dr. Julia Guzmán of the Colombian potato research program spent nearly three months in Mexico studying the reaction of Colombian selections to the late-blight pathogen at Toluca. This visit represents a cooperative effort in late-blight research between the Colombian and Mexican programs. Early significant progress in this project augurs well for the future of this collaboration.

Dr. Eugenio Schieber, head of the potato research in Guatemala, visited Mexico for one month in August, 1961, and saw much of the Mexican potato research program at that time. As a result of his visit, closer research ties were established with the Guatemalan group. Mexican selections were sent to Guatemala for testing in several locations there. Chemical analyses of the tubers of these selections, produced in Guatemala, were made in Dr. Schieber's laboratory and revealed important information on the comparative nutritional value of these selections.

VISITORS

During 1961, a number of potato research scientists from many parts of the world visited the Mexican potato research center. Among these visitors were:

Dr. Malcolm Driver, principal potato breeder of the Ministry of Agriculture, New Zealand; one week, August, 1961.

Dr. Robert W. Hougas, leader of the USDA Potato Introduction Station at Sturgeon Bay, Wisconsin, and professor of genetics, University of Wisconsin; two weeks, December, 1961.

Dr. Kenneth Proudfoot, potato breeder for the Ministry of Agriculture, Northern Ireland; July, 1961.

International Rice Research Institute

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* On assignment from The Rockefeller Foundation.

The plant-growth experimentation center.

Director's Report

The International Rice Research Institute, established and currently maintained by the Ford and Rockefeller Foundations with the cooperation of the Government of the Philippines, is an organization devoted principally to the study and improvement of rice. Its location is adjacent to the College of Agriculture of the University of the Philippines at Los Baños, 40 miles south of Manila.

The primary purpose of the Institute is to conduct basic and applied research on the rice plant, directed toward improving its productivity and quality. In addition, the Institute maintains a library and documentation center; conducts regional projects in the agricultural sciences in cooperation with established research and educational institutions; and has a resident training program in rice research methods and techniques.

A description of the physical plant appeared in last year's report. It is worthy of note that all construction proceeded in accordance with the original plan, the last major building having been finished on January 16, 1962, five days ahead of schedule.

A successful and memorable dedication ceremony was held at the Institute on February 7, 1962. The bronze plaque in the center of the plaza was unveiled by Mrs. Diosdado Macapagal, the First Lady of the Philippines, assisted by Mrs. John D. Rockefeller, 3rd. After this event, which took place at ten o'clock in the morning, formal ceremonies were held in the Institute's auditorium. The major address was given by the President of the Republic of the Philippines, Diosdado Macapagal. Greetings were extended by Mr. John D. Rockefeller, 3rd, Chairman of the Board

Planting part of the world rice collection.

of Trustees of The Rockefeller Foundation; by Dr. Forrest F. Hill, Vice President of The Ford Foundation; and by Dr. K. R. Damle on behalf of the Board of Trustees of the International Rice Research Institute. The President of The Rockefeller Foundation, Dr. J. G. Harrar, who is also Chairman of the Board of Trustees of the Institute, and Dr. Robert F. Chandler, Jr., the Institute Director, presided.

Besides the participants already mentioned, the platform party, who were introduced individually, included the Vice President of the Philippines, the members of the Board of Trustees of the Institute, the Vice President for Agricultural Affairs of the University of the Philippines, and the architects who designed the Institute buildings and staff houses.

The auditorium was filled to its capacity of 260 persons, and an additional 300 people watched the program on closed-circuit television in another room. Invited guests included members of the diplomatic corps, of the presidential cabinet, and of the Board of Regents of the University of the Philippines, as well as prominent citizens, government officials, and faculty members of the College of Agriculture.

In addition to an appropriation from The Rockefeller Foundation to cover the general operating costs of the Institute during 1962, a substantial grant was received from The Ford Foundation as a contribution to the Institute's regional training and research program.

The training program of the Institute is now in operation. As of June 1, 1962, 24 research scholars have been enrolled, most of whom are also registered as graduate students at the nearby College of Agriculture of the University of the Philippines. When this program is fully developed, it is expected that up to 60 research scholars will be receiving training in research techniques under the guidance of the senior scientists of the Institute. In the years ahead these scholars should be able to achieve for their home countries a significant improvement in the quantity and quality of rice research and, ultimately, of rice production.

The library-documentation center is progressing well. By late 1962, a ten-year (1951–1961) bibliography of technical rice literature will have been compiled, and essentially all of the 10,000 to 12,000 citations will have been microfilmed and placed in the library. Dr. Jukyu Cho, a staff member of the Institute stationed in Japan, maintains an up-to-date bibliography of Japanese rice literature and arranges for translations into English of significant Japanese scientific articles. The library subscribes on a continuing basis to more than 270 scientific journals and periodicals. Approximately 20,000 books and other materials have been purchased and catalogued during the past year. The aim of the library is to accumulate an essentially complete collection of the world's technical literature on rice.

The Institute has under lease from the University of the Philippines a total of 99.2 hectares of land. Approximately 19 hectares are occupied by buildings, and the remaining 80 hectares are used for experimental fields. A portion of this land, however, is taken up by roads, streams, plot borders, etc., leaving an effective area of 55.4 hectares for experimental plots.

During the past year an underground irrigation system was installed in the plots, new access roads were built, and the land was leveled to permit irrigation of each plot at a controlled water depth.

The Bureau of Soils of the Department of Agriculture and Natural Resources of the Philippines provided two of its staff to make a detailed soil survey of the experimental fields of the Institute and to prepare a soil map at a scale of 1:3000.

Land not needed for experimental purposes is used for producing certified seed of rice varieties recommended by the Bureau of Plant Industry of the Philippines. In 1961 approximately 40 hectares were devoted to such seed production, and thus a modest contribution was made to the supply of good seed in the Philippines.

The design and development of the experimental fields were handled by the Agricultural Engineering Department and constituted a full-time operation. Now that this developmental work is nearing completion, the agricultural research program will be able to proceed.

As for the over-all research program of the Institute, it is still too early to report any results. Brief descriptions of certain research projects that were in progress by July of 1962 are, however, given below.

VARIETAL IMPROVEMENT

The varietal improvement program has made exceptional progress toward establishing a world collection of rice varieties. Beginning in November, 1961, requests for seed samples were sent to 45 rice-producing countries. The response was excellent and over 6,000 varieties and genetic lines were received. All these samples were assigned accession numbers, planted in seed beds, and transplanted by the first week of June, 1962.

After appropriate field observations have been recorded, each variety will be catalogued in accordance with important plant and grain characteristics. Pure seed of each variety or line will be kept in cold storage where there will be little loss of viability over a 10- to 15-year period. This collection will serve as a germ plasm bank for rice seed exchange on a world-wide basis. Already seed samples of over 260 varieties have been sent to other countries, at their request.

In addition, plots have been established for increasing seeds of genetic testers, of progenies of irradiated material, and of lines possessing other special characteristics of importance to a breeding program. Certain named varieties of particular interest are being planted in seed-increase blocks. Some of these, such as the *Japonica* varieties from Taiwan, have been planted in yield trials along with some of the more promising *Indica* varieties.

Another phase of the varietal improvement program is an investigation of yield components in *Indica* and *Japonica* varieties. Briefly, these studies consist of planting a series of varieties that differ in tillering ability, panicle size, and seed weight, and subjecting them to various nitrogenous fertilizer treatments. The studies should reveal the heritability values of the yield components (panicles per plant, seeds per panicle, and weight per seed) as selection criteria in breeding programs and should indicate, also, the response of the different varieties to nitrogen fertilization in terms of the yield components mentioned above.

Agronomy and Soils

The effects of the herbicide STAM F-34 on the control of weeds in direct-seeded rice are being studied. The treatments range from zero to as high as 16 kg./ha. of STAM, with five upland and five lowland rice varieties in the test.

Green manure crops for tropical rice are being investigated with three principal objectives: to measure growth and productivity of promising tropical legumes under upland and lowland conditions; to evaluate the crop residues as green manures for rice; and to increase the seed supply of the less common but potentially important legumes.

Various methods of weed control on non-crop areas, such as levees, ditches, and roadsides, are being compared. Chemical weedicides, burning, and hand methods are included in the study.

A maximum-yield experiment has been started. Undoubtedly, it will take a few years to obtain exceptionally high yields, but the best known practices are being followed. The experimental design is such that different management systems can be compared, to evaluate their contribution to yield. The factors varied in the treatment include water management, amount and time of application of fertilizer, kinds and amounts of green manure, spacing, and weed control. Both *Japonica* and *Indica* varieties are included in the test.

The chemistry of iron compounds in flooded soils is being studied, as well as the influence of reduced iron on ionic equilibria under anaerobic conditions.

The factors that influence the course of decomposition of organic matter in anaerobic soils are being investigated, and identification of the products is being attempted by a combination of gas and paper chromatography.

The electrochemistry of submerged soils is being studied under the following headings: redox systems in submerged soils, redox potential as a diagnostic tool in the study of reduced soils, and the interpretation of quantitative changes in specific conductance and pH.

Under the general heading of the chemical kinetics of submerged soils, the changes in concentration with time are being studied for the following elements or ions: iron, manganese, nitrate, nitrite, ammonium, silicon, potassium, and phosphorus. Quantitative correlation of these changes with initial chemical and physicochemical analyses of the soil will be attempted.

Transplanting variety trials.

The iron nutrition of the rice plant is being studied in culture solution under a variety of conditions known to influence the availability of iron. A delimitation of the optimum range and of deficiency and toxicity will be attempted.

The influence of the water regime on rice is being investigated by growing plants outdoors in large drums. Conditions in the root zone will be characterized chemically and physicochemically, and an interpretation of growth and yield will be attempted in terms of these analyses.

PLANT PROTECTION

The current plant pathology research program is largely concerned with the rice blast disease, *Piricularia oryzae*. All the several thousand varieties in the world collection are being tested for resistance to this disease. Studies are being made of the seasonal distribution and dissemination of spores. Identifications of physiologic races of the blast pathogen are being made, and detailed laboratory studies of the individual variants are under way.

The entomology program is concentrated on studies of the rice stem borer, by far the most serious insect pest of rice. At present three major projects are being conducted.

One is a study of the resistance of different rice varieties to the stem borer; it includes the following phases: the development of techniques for the mass rearing of borers, the screening of rice varieties in the field for resistance (249 varieties are now being tested), detailed observations of ovipositional response of the insects to different varieties, and intensive greenhouse testing of varieties that show resistance under field conditions.

The second is a study of insecticides for the control of stem borers. Special attention is being given to insecticides with a long residual effect and these are being tried as a seed dip, as a dip for seedlings at the time of transplanting, and as a spray after transplanting.

Plant breeders inspecting rice plants.

The rice moth and the rice weevil, both serious pests of stored rice grain, are being studied with three initial objectives: to determine the source of infection in the storage area, to measure the influence of temperature and humidity on the development of insects in stored grain, and to investigate the feasibility of storing grain under airtight conditions.

The entomology program also includes a survey of the area around Los Baños to determine the occurrence of different species of insects affecting rice, and to learn whether the population counts bear any relationship to the stages of development of the rice plant. Another project is to study more intensively, under greenhouse conditions, the effect on the development of the rice plant of different numbers of rice borer larvae implanted at various physiological stages.

Plant Physiology

One of the major current projects in plant physiology is a study of the response of *Japonica* and *Indica* varieties to nitrogenous fertilizers at different planting distances. Nitrogen applications vary from zero to 120 kg./ha., and spacings range from 10 × 10 centimeters to 60 × 60 centimeters. Three varieties are included in the study: Peta, a tall *Indica* variety with little sensitivity to day-length; BPI-76, a relatively short *Indica* variety which is sensitive to day-length; and Tainan 3, a *Japonica* variety developed in Taiwan. Detailed records are being kept on height, number of tillers, length of leaves and internodes, and yield of straw and grain. Samples of straw and grain from each treatment will be analyzed for nitrogen, phosphorus, potassium, calcium, and silicon. The nitrogen and carbohydrate contents of the plants will be determined at the time of tillering, of ear initiation, of heading, and of harvest.

To supplement this comprehensive field experiment, studies will be made in the Institute's plant-growth chambers to determine the response of each of the three varieties to temperature, light intensity and quality, and day-length.

As a further supplement to these studies, the movement of carbohydrates at the different physiological stages will be measured by the use of Carbon 14.

Another plant physiology project is a detailed study of weeds commonly present in rice fields under tropical conditions. One phase of this research is a comparison of the effect of different levels of submergence on seed germination and seedling survival. These investigations are being made under controlled temperature and light conditions, with the water depth varying from zero to 15 centimeters. A study of the life cycles of the common weeds is also in progress. The following characteristics will be recorded for each species: number of days required to complete the life cycle, final height (or length, if prostrate), date of flowering, date of maturity, and type of seed dispersal.

CHEMISTRY

The principal project now active in the chemistry department is an investigation of the chemical basis of rice quality which will include the following major studies: (a) an elucidation of the characteristics of rice starch granules related to the cooking process, such as sorption of water, retrogradation, gelatinization, and alkali dispersability; (b) a study of the chemical explanation of the glutenous quality of rice (this quality, although widely recognized as a distinguishing characteristic among certain types of rice, has never been satisfactorily explained chemically); (c) a study of the relationship between milling quality and chemical composition, including the effect of internal structure and opacity of the grain; (d) a study of the chemical nature of the aroma quality in rice; and (e) the development of new and improved methods for the determination of rice quality.

The chemistry department handles all routine analyses of rice for programs such as varietal improvement and agronomy that do not have their own chemical facilities.

REGIONAL RESEARCH PROJECTS

With the support of The Ford Foundation grant mentioned earlier, regional research projects are being undertaken with research and educational institutions in various rice-growing countries in Asia. The Institute furnishes advisory help in planning the projects and in interpreting the results. It may also furnish limited funds for supplies and for local labor when needed. The major research staff and facilities are provided by the cooperating institutions.

Among the projects now being started with various countries are an exhaustive search for rice varieties in all rice-growing nations of Asia, a standard rice blast testing program, and cooperative studies in the development of rice cultivation machinery.

This phase of the Institute's program is just beginning and will be expanded greatly during the next year.

Now that the major construction work is finished and most of the scientific staff engaged, the International Rice Research Institute is prepared to develop and maintain a vigorous and effective research program designed to answer age-old problems of the cultivation of rice, the principal staple food for more than half of mankind.

FELLOWSHIPS AND SCHOLARSHIPS

AID TO RESEARCH AND TEACHING

PUBLICATIONS 1961–1962

Fellowships and Scholarships

Active from July 1, 1961, to June 30, 1962

The Fellowship and Scholarship Program in the Agricultural Sciences continues to require a budget of more than one million dollars annually. This is evidence of The Rockefeller Foundation's belief that by providing training opportunities for increasing numbers of young men and women in agricultural research it can materially assist the advancing countries in their efforts to achieve more adequate food production and improved levels of living.

An indication of the value of this investment in the development of trained scientific manpower is afforded by the number of former Foundation fellows and scholars appointed from the Mexican Agricultural Program who have returned to work with the program and assume important responsibilities for the future of Mexican agriculture. The Director General, the Subdirector General, and the Technical Subdirector of the recently formed National Institute of Agricultural Research all received training under Foundation fellowships. Fourteen of the department heads and many of the directors and managers of the experiment stations are likewise former Foundation fellows or scholars.

There were 297 fellowships and scholarships active during the year ending June 30, 1962, with representation from faculties of agriculture and veterinary science, research institutes, and government agencies in 28 countries.

Major emphasis is being given to the training of young Latin American scientists, especially those associated directly or indirectly with the operating programs. Nearly 60% of the total number of appointees, or 176, come from Latin America, including 60 from Mexico, 34 from Colombia, and 22 from Chile.

There has been an increase in the number of awards made in the Far East and South Asia—108 this year as compared with the previous 81. India, with 37 appointees, again heads the list, followed by the Philippines with 28 and Japan with 18.

The African program also shows an increase, which reflects the Foundation's search for useful opportunities to support postgraduate training for young Africans. During the year appointments have been held by three scientists from Ethiopia and one each from Ghana, the Sudan, and Uganda. As explained in the 1960–1961 report, the number of Polish appointees has been considerably reduced.

During the period covered by this report, fellows and scholars studied at 40 different institutions in the United States and at 7 abroad. Following is a list of the major institutions in the order of the number of Foundation appointees at each:

Cornell University	39
University of California	39
Davis—27	
Berkeley—9	
Riverside—3	
North Carolina State College	31
University of Wisconsin	22
Iowa State University	15
Purdue University	15
University of Minnesota	14
Michigan State University	12
University of Nebraska	11
Kansas State University	7
Oregon State University	7
Utah State University	6
Colorado State University	5
University of Florida	5
University of Illinois	5
Louisiana State University	5
Oklahoma State University	5
North Dakota Agricultural College	4
Pennsylvania State University	3
Rutgers University	3

The appointees in active status during the year ending June 30, 1962, are listed in the following pages by country and sponsoring institution. The name of the fellow (F) or scholar (S) is followed by the general area of study and by the name of the study post.

ARGENTINA

National Institute of Agricultural and Livestock Technology, Buenos Aires

s **Arias, Hipolito Leandro,** Economics & Rural Life, Cornell University
s **Calderoni, Atilio Víctor,** Plant Pathology, Mexican Agricultural Program
s **Castelli, Luis Angel,** Economics & Rural Life, Cornell University
s **Chabrillon, Alberto Luis,** Genetics & Plant Breeding, Mexican Agricultural Program
s **Ernié, Enrique René,** Soil Science, Mexican Agricultural Program
s **Galli, Ignacio Osvaldo,** Animal Husbandry, University of Florida
s **Goldenberg, José Bernardo,** Genetics & Plant Breeding, North Carolina State College
s **González Padilla, Alejandro G.,** Economics & Rural Life, University of Wisconsin
s **Induni, César Juan,** Genetics & Plant Breeding, University of Wisconsin
s **Moro, Marta Susana,** Chemistry, Kansas State University
s **Tiranti, Iván Nicolás,** Genetics & Plant Breeding, Texas Agricultural and Mechanical College
s **Vergani, Aldo Raúl,** Entomology, University of California, Riverside
s **Von Der Pahlen, Alejo Wendt P. R.,** Genetics & Plant Breeding, University of California, Davis

AUSTRALIA

University of Sidney

F **Crofts, Frank Clement,** Agronomy, Oregon State College

BOLIVIA

University of San Simón, Cochabamba

s **Candia Zeballos, José Daniel,** Entomology, Cornell University
s **Cosío Montano, Carlos,** Genetics & Plant Breeding, North Carolina State College
s **Herbas Arce, Remberto,** Plant Pathology, University of California, Berkeley

LA TAMBORADA AGRICULTURAL EXPERIMENT STATION

s **Ayala Zambrana, Jorge,** Poultry Husbandry, Mexican Agricultural Program

BRAZIL

Desiderio Finamor Institute of Veterinary Research, Guaiba, Rio Grande do Sul

F **Mancuso, Pedro Carlos,** Veterinary Science, University of California, Davis

Institute of Biology, São Paulo

s **Varoli, Gilda,** Library Science, U.S. Department of Agriculture Library

Ministry of Agriculture

AGRONOMIC INSTITUTE OF THE SOUTH, PELOTAS, RIO GRANDE DO SUL

s **Liberal, Mozart Teixeira,** Genetics & Plant Breeding, University of Wisconsin
s **Vernetti, Francisco de Jesus,** Genetics & Plant Breeding, Purdue University

INSTITUTE OF ANIMAL BIOLOGY

s **Dobereiner, Jürgen,** Veterinary Science, University of Wisconsin

NATIONAL CENTER FOR AGRICULTURAL RESEARCH AND EDUCATION

s **Braun, Walter Augusto Gross,** Soil Science, University of California, Davis

São Paulo State Secretariat of Agriculture, São Paulo
- s **Cintra, Benjamin,** Economics & Rural Life, North Carolina State College

University of Minas Gerais, Belo Horizonte
- s **Monteiro, Warton,** Genetics & Plant Breeding, North Carolina State College

University of Paraná, Curitiba
- s **Veiga, Luiz Alberto Silva,** Chemistry, University of California, Berkeley

University of São Paulo, Luiz de Queiroz College of Agriculture, Piracicaba
- s **Bergamin Filho, Henrique,** Chemistry, University of Illinois
- s **Blumenschein, Almiro,** Genetics & Plant Breeding, North Carolina State College
- s **Dias, Domiciano Pereira de Souza,** Entomology, University of Kansas
- s **Haag, Henrique Paulo,** Plant Physiology, University of California, Davis
- F **Ranzani, Guido,** Soil Science, Cornell University

CEYLON

Department of Agriculture, Peradeniya
- s **Ariyanayagam, David Veluppillai,** Genetics & Plant Breeding, University of California, Davis
- F **Jayaweera, Don Martin Arthur,** Botany, Harvard University
- s **Marks, Geoffrey Charles,** Plant Pathology, University of Wisconsin

Dry Zone Research Station, Maha
- s **Alles, Wajiraransi Saddhani,** Soil Science, Ohio State University

CHILE

Catholic University of Chile, Santiago
- s **Trivelli Gandal, Osvaldo,** Genetics & Plant Breeding, Mexican Agricultural Program

Ministry of Agriculture

central experiment station, santiago
- s **Avendaño, Raúl E.,** Agronomy, Purdue University
- s **Ortiz, Fernando C.,** Genetics & Plant Breeding, Cornell University
- s **Parodi Pinedo, Patricio,** Genetics & Plant Breeding, Purdue University
- s **Ramírez Araya, Ignacio,** Genetics & Plant Breeding, Washington State University

department of agricultural production and fisheries
- F **Cortázar Sagarmínaga, René,** Genetics & Plant Breeding, University of Minnesota

department of agricultural research
- s **López Villanueva, Hernán,** Plant Physiology, Oregon State University
- s **Valdivia Bugueno, Vital,** Genetics & Plant Breeding, University of Minnesota
- s **Violic Martinovic, Alejandro,** Genetics & Plant Breeding, University of Minnesota

office of special studies
- s **Cubillos Oyarzo, Gustavo,** Agronomy, Purdue University
- s **Vicens Obrador, José Jaime,** Agronomy, University of Adelaide, Australia

south-central experiment station, chillán
- s **Bonilla Espíndola, Sergio,** Animal Nutrition, University of California, Davis

SOUTHERN EXPERIMENT STATION, TEMUCO

- s **Acevedo, Juan,** Genetics & Plant Breeding, Cornell University
- s **Cubillos Plaza, Alberto,** Plant Pathology, Mexican Agricultural Program and Colombian Agricultural Program
- s **Fernandez de Cubillos, Luz del Carmen,** Plant Pathology, Mexican Agricultural Program and Colombian Agricultural Program
- s **Müller Osinaga, Guillermo,** Soil Science, Mexican Agricultural Program

UNIVERSITY OF CHILE, SCHOOL OF AGRICULTURE, SANTIAGO

- s **Contreras Tapia, David,** Agronomy, Oregon State University
- s **González Rodríguez, Roberto,** Entomology, University of California, Davis
- s **Gastó Coderch, Juan,** Agronomy, Colorado State University
- s **Moyano, José Gregorio,** Soil Science, University of California, Davis
- s **Rodriguez Veliz, Sergio,** Horticulture, Cornell University
- s **Sánchez Arellano, Luis,** Genetics & Plant Breeding, Cornell University

COLOMBIA

MINISTRY OF AGRICULTURE, DIVISION OF AGRICULTURAL RESEARCH

- s **Acosta Jarma, Luis Oswaldo,** Animal Nutrition & Physiology, Cornell University
- s **Alvárez Rico, José Manuel de Bernardo,** Animal Nutrition & Physiology, Purdue University
- s **Barriga Olivares, Rodolfo,** Plant Pathology, North Carolina State College
- F **Camacho, Luis H.,** Genetics & Plant Breeding, North Carolina State College
- s **Cardona Alvarez, Oscar,** Animal Science, Oklahoma State University
- F **Cassalett Davila, Clímaco,** Genetics & Plant Breeding, Cornell University
- s **Chaverra G., Hernán,** Agronomy, Purdue University
- F **Echeverri E., Silvio,** Agronomy, Oregon State University
- F **Estrada Ramos, Nelson,** Genetics & Plant Breeding, University of Wisconsin
- s **Fonseca M., Santiago,** Genetics & Plant Breeding, Purdue University
- s **Gálvez Enriquez, Guillermo Edmundo,** Plant Pathology, University of Nebraska
- s **Guerrero Muñoz, Ramiro,** Soil Science, Cornell University
- s **León Sarmiento, Luis Alfredo,** Soil Science, North Carolina State College
- s **López Ocampo, Rafael,** Plant Pathology, University of Minnesota
- s **López Rubio, Hernán,** Veterinary Science, University of Minnesota
- F **Lotero C., Jaime,** Soil Science, North Carolina State College
- s **Lujan Claure, Lauro,** Horticulture, Cornell University
- s **Madiedo Mendez, Gonzalo,** Poultry Husbandry, University of Wisconsin
- s **Marin Morales, José Gildardo,** Soil Science, North Carolina State College
- s **Mateus Valles, José Guillermo,** Entomology, University of Wisconsin
- s **Oñoro-Cerra, Pedro Raúl,** Biometry, North Carolina State College
- s **Patiño Hernández, Omar,** Animal Husbandry, University of California, Davis
- s **Quintero Pinto, Jorge,** Engineering, University of California, Davis
- s **Ramírez Ospina, Rodrigo,** Agronomy, North Carolina State College
- F **Revelo Pepinosa, Miguel A.,** Entomology, Iowa State College
- s **Sánchez Farrut, Otto Hernando,** Veterinary Science, Colorado State University
- s **Sohm Kuhne, Oscar Dieter,** Genetics & Plant Breeding, Louisiana State University

F **Torregroza Castro, Manuel,** Genetics & Plant Breeding, University of Missouri

S **Van Cotthem M., Luis Carlos,** Animal Physiology, Oklahoma State University

F **Zapata Balcázar, José Mario,** Genetics & Plant Breeding, North Dakota Agricultural College

NATIONAL UNIVERSITY, COLLEGE OF AGRICULTURE, MEDELLÍN

F **Ospina, Oscar,** Soil Science, University of California, Berkeley

UNIVERSITY OF CALDAS, MANIZALES

S **Mejia, Giraldo Germán,** Soil Science, Purdue University

S **Muñoz Dávila, Alvaro,** Veterinary Science, University of Illinois

F **Vélez Ramírez, Hildebrando,** Veterinary Science, Biological Institute, São Paulo, Brazil

COSTA RICA

INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES, TURRIALBA

S **Bornemisza, Elemer,** Soil Science, University of Florida

F **Carballo Quiros, Alfredo,** Genetics & Plant Breeding, North Carolina State College

F **Díaz Bordenave, Juan Enrique,** Economics & Rural Life, Michigan State University

S **Jiménez Saenz, Eduardo,** Plant Physiology, Michigan State University

ECUADOR

CENTRAL UNIVERSITY, QUITO

S **Guerrero P., Tomás A.,** Horticulture, University of California, Davis

INTER-AMERICAN AGRICULTURAL COOPERATIVE SERVICE, QUITO

S **Paladines Mosquera, Osvaldo Leonel,** Animal Husbandry & Nutrition, Cornell University

MINISTRY OF DEVELOPMENT, NATIONAL WHEAT COMMISSION, QUITO

S **Romero Romo, Galo Edmundo,** Genetics & Plant Breeding, Iowa State University

UNIVERSITY OF GUAYAQUIL

S **Avila Medina, Quinto,** Poultry Husbandry, Mexican Agricultural Program

ETHIOPIA

IMPERIAL ETHIOPIAN COLLEGE OF AGRICULTURAL AND MECHANICAL ARTS, DIRE DAWA

S **Belay, Haile Selassie,** Economics & Rural Life, Cornell University

S **Melak Hail Mengesha,** Genetics & Plant Breeding, Purdue University

MINISTRY OF AGRICULTURE, ADDIS ABABA

S **Mengesha, Hailu,** Genetics & Plant Breeding, Oklahoma State University

GHANA

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

S **Sey, Samuel,** Economics & Rural Life, University of California, Berkeley, and Wye College, England

GUATEMALA

National Agricultural and Livestock Institute, La Aurora
- s **Sosa Sandoval, Oscar Nery,** Plant Pathology, University of Minnesota

National Livestock Institute, Quezaltenango
- s **Juárez Pérez, Jorge Luis,** Genetics & Plant Breeding, Mexican Agricultural Program

INDIA

Agricultural College and Research Institute, Coimbatore
- s **Seshadri, A. R.,** Nematology, University of California, Davis

Banaras Hindu University, Varanasi
- s **Kaul, Ravindra Nath,** Agricultural Engineering, North Carolina State College

Central Rice Research Institute, Cuttack
- s **Chaudry, Mahabir Singh,** Agronomy, Ohio State University
- F **Govindaswami, Sivaram,** Agronomy & Plant Genetics, University of California, Davis

Government of Andhra Pradesh, Department of Agriculture, Hyderabad
- s **Ali, Syed Mahboob,** Genetics & Plant Breeding, University of Minnesota
- s **Narayan, Kishen,** Genetics & Plant Breeding, Texas Agricultural and Mechanical College
- s **Pillay, Trichinopoly Nataraj Dathathry,** Horticulture, Cornell University
- s **Ramana Murthy, Gundugurthy Venkata,** Genetics & Plant Breeding, University of California, Davis
- s **Venkataswamy, Tady,** Genetics & Plant Breeding, Louisiana State University

Government of Bihar, Department of Agriculture, Bhagalpur
- F **Jha, Kali Kant,** Soil Science, University of Wisconsin

Government of Himachal Pradesh, Department of Agriculture, Simla
- F **Bhardwaj, Bhup Dev,** Genetics & Plant Breeding, University of Minnesota
- s **Saini, Sarup Singh,** Genetics & Plant Breeding, University of California, Davis
- s **Thakur, Parkash Chand,** Soil Science, University of California, Berkeley

Government of Madhya Pradesh, Agricultural College and Research Institute, Gwalior
- s **Gaur, Ram Autar,** Economics & Rural Life, Cornell University
- s **Jethmalani, Shampal Chuharmal,** Agronomy, Utah State University
- s **Solanki, Sadhu S. S.,** Agronomy, University of Wisconsin
- s **Sharma, Veda Vrata,** Dairy Husbandry, Iowa State University
- s **Verma, Gopal Prasad,** Soil Science, Iowa State University

Government of Punjab, Department of Agriculture, Patiala
- s **Sekhon, Gurcharan Singh,** Agronomy, Iowa State University

Government of Uttar Pradesh, Department of Agriculture, Lucknow
- s **Singh, Sher,** Economics & Rural Life, Cornell University

Government of West Bengal, Department of Agriculture, Calcutta
- F **Banerjee, Sourendra Nath,** Entomology, Cornell University
- F **Basak, Megh Nath,** Soil Science, University of California, Berkeley
- s **Ghose, Suva,** Genetics & Plant Breeding, University of Minnesota
- s **Mukherjee, Debabrata,** Genetics & Plant Breeding, University of Minnesota

Home Science Wing, Rajendranagar, Hyderabad
- s **Kamala Chinniah, Thumala Chetty,** Home Economics, Iowa State University

Institute of Agriculture, Anand

- F **Patel, Kanubhai Arvindbhai,** Genetics & Plant Breeding, North Carolina State College
- F **Patel, Ramjibhai Madhavbhai,** Biometry, North Carolina State College
- F **Shah, Champaklal Bhogilal,** Plant Physiology, University of California, Davis

Karnatak University, Mysore

- S **Patil, Siddangouda Venkangouda,** Agronomy, Utah State University

Ministry of Food and Agriculture, New Delhi

- S **Chopra, Kuldip Raj,** Genetics & Plant Breeding, University of Nebraska and Mexican Agricultural Program
- S **Gupta, Dalip Singh,** Entomology, Cornell University
- S **Randhawa, Narindar Singh,** Economics & Rural Life, Iowa State University
- S **Sharma, Jagdish Chandra,** Economics & Rural Life, Cornell University

Rajasthan College of Agriculture, Udaipur

- S **Saraswat, Devi Singh,** Dairy Husbandry, Iowa State University

S. K. N. Government College of Agriculture, Jobner, Jaipur

- S **Kumar, Sudhir,** Horticulture, Washington State University
- F **Singh, Gajadhar,** Soil Science, University of California, Davis
- F **Srivastava, Brajendra Prasad,** Entomology, Kansas State University

INDONESIA

University of Indonesia, Bogor

faculty of agriculture

- S **Karhi Sukartaatmadja,** Botany, University of California, Davis
- F **Tan, Kim Hong,** Soil Science, Cornell University

faculty of veterinary science

- S **Soekotjo, Wirasmono,** Veterinary Science, Michigan State University

ISRAEL

Hebrew University, Jerusalem

- F **Neumann, Joseph,** Plant Physiology, Brandeis University

JAPAN

Fukushima Livestock Breeding Station

- S **Ishihara, Shuji,** Agronomy, Oregon State University

Hokkaido National Agricultural Experiment Station, Sapporo

- F **Okabe, Shiro,** Genetics & Plant Breeding, Iowa State University

Hokkaido University

faculty of agriculture

- F **Ishikawa, Yoshinori,** Chemistry, University of Vermont
- F **Okazawa, Yozo,** Plant Physiology, Colorado State University

faculty of fisheries

- F **Nishizawa, Satoshi,** Marine Resources, Yale University

Kyoto University

- S **Kawashima, Ryoji,** Animal Husbandry, Iowa State University
- F **Kyuma, Kazutake,** Soil Science, North Carolina State College

Kyushu National Agricultural Experiment Station, Kumamoto

- S **Suzuki, Akira,** Soil Science, Michigan State University

Kyushu University, Faculty of Agriculture, Fukuoka
- F **Yamada, Yoshio,** Soil Science, Rothamsted Experimental Station, Harpenden, England, and U.K. Atomic Energy Research Establishment, Harwell

Ministry of Agriculture and Forestry, Tokyo
- S **Abiko, Chie,** Home Economics, Michigan State University

Nagoya University, Faculty of Agriculture, Anjo
- F **Kuyama, Shimpei,** Microbiology, Rutgers University

National Institute of Agricultural Sciences, Chiba-City
- F **Namioka, Shigeo,** Veterinary Science, Cornell University

National Institute of Genetics, Misima
- F **Iyama, Shin-ya,** Genetics & Plant Breeding, University of Minnesota

Okayama University, Ohara Institute for Agricultural Biology, Kurashiki
- F **Hiura, Unji,** Plant Pathology, University of Minnesota

Tohoku University, Faculty of Agriculture, Sendai
- F **Adachi, Susumu,** Dairy Science, Pennsylvania State University
- S **Ohira, Koji,** Chemistry, Cornell University

Tokyo University, Faculty of Agriculture
- S **Sasaki, Toshio,** Library Science, Columbia University

University of Osaka Prefecture, Sakai City
- F **Imori, Tatuo,** Veterinary Science, Oklahoma State University

MEXICO

Technological Institute and School of Advanced Studies, Monterrey
- F **de Alba Flores, Gabino,** Genetics & Plant Breeding, University of Wisconsin
- F **Fuente Villarreal, Jesús Mario de la,** Entomology, Cornell University
- F **Leal Díaz, Jaime,** Soil Science, University of California, Davis
- F **Rivera Camarena, Jorge Enrique,** Plant Pathology, University of Florida

Ministry of Agriculture, National Institute of Agricultural Research
- F **Aguilera Amezcua, Augusto,** Animal Science, University of Illinois
- S **Amaya Celis, Arnoldo,** Agronomy, North Dakota State University
- S **Andrade, Francisco Jacinto,** Agricultural Economics, University of Wisconsin and North Carolina State College
- S **Angli, José Soto,** Economics & Rural Life, Purdue University
- S **Bixler, Edsel George,** Poultry Science, University of Maryland
- S **Campos Vela, Armando, VI,** Plant Pathology, University of Wisconsin
- S **Carmona Ruiz, Gildardo,** Soil Science, Cornell University and University of Tennessee
- S **Carrillo Sánchez, José Luis,** Entomology, Oregon State College
- F **Chena González, Rodolfo,** Economics & Rural Life, Cornell University
- S **Cota Agramont, Oscar,** Genetics & Plant Breeding, North Carolina State College
- S **de las Casas Aguirre, Ernesto,** Entomology, University of Minnesota
- F **Galindo Alonso, Jorge,** Plant Pathology, University of California, Berkeley and Riverside
- F **García Sánchez, Alfredo,** Agronomy, Kansas State University
- F **Garza Trevino, Ricardo,** Agronomy, Purdue University
- F **González Alanis, Martín H.,** Agronomy, Utah State University

- s **Jiménez Sánchez, Leobardo,** Agricultural Journalism, University of Wisconsin
- s **Kato Yamakake, Takeo Angel,** Genetics & Plant Breeding, North Carolina State College
- F **Kohashi Shibata, Josué,** Plant Physiology, Harvard University
- s **León Manzo, Ricardo,** Plant Physiology, University of California, Berkeley
- s **López Frias, Luis César,** Plant Pathology, University of Minnesota
- s **Márquez Sánchez, Fidel,** Genetics & Plant Breeding, Iowa State University
- s **Martínez, Gregorio,** Economics & Rural Life, University of Wisconsin
- F **Martínez Salazar, Eugenio,** Plant Pathology, University of Wisconsin
- s **Merino Irigoyen, Rubén,** Plant Pathology, Pennsylvania State University
- s **Miranda Colín, Salvador,** Genetics & Plant Breeding, University of California, Davis
- s **Moncada de la Fuente, Jesús,** Soil Science, North Carolina State College
- s **Muñoz Flores, Ignacio,** Genetics & Plant Breeding, University of California, Davis
- F **Munoz Garza, Juan Manuel,** Agronomy, University of Nebraska
- s **Navarro Franco, Manuel,** Agronomy & Plant Pathology, University of Wisconsin
- s **Nieto, Victor,** Horticulture, University of California, Los Angeles and Riverside
- F **Nieto Hatem, Jorge,** Plant Physiology, Iowa State University
- s **Olmos Barrera, Gil,** Economics & Rural Life, University of Wisconsin
- s **Ortíz Cereceres, Joaquín,** Genetics & Plant Breeding, Iowa State University
- s **Padilla Aranda, Rafael,** Entomology, University of Massachusetts
- F **Patiño Mendez, Graciano,** Plant Pathology, University of California, Davis
- s **Pérez Ugalde, Gelacio,** Genetics & Plant Breeding, University of Wisconsin
- s **Pineda, Reynaldo Luis,** Agronomy, University of Hawaii
- s **Puente Flores, Fidencio,** Soil Science, North Carolina State College
- s **Ramírez Paz, Félix,** Soil Science, Purdue University
- s **Serrano Palencia, José Luis,** Horticulture, University of Nebraska
- F **Sifuentes Aguilar, Juan Antonio,** Entomology, Kansas State University
- s **Solana-Martagón, Pedro,** Veterinary Science, University of Wisconsin
- F **Vázquez Guillén, Gregorio,** Genetics & Plant Breeding, North Dakota State University
- s **Velasco, Marcial,** Animal Nutrition & Physiology, Oklahoma State University
- s **Villanueva Barradas, Juan Rigoberto,** Entomology, University of California, Davis
- s **Villegas Moreno, Evangelina,** Chemistry, Kansas State University
- s **Wing Martínez, Marco Antonio,** Genetics & Plant Breeding, University of Nebraska

NATIONAL SCHOOL OF AGRICULTURE, CHAPINGO

- F **Brauer Herrera, Oscar,** Genetics & Plant Breeding, University of Göttingen, Germany
- s **Echegaray Alemán, Alfredo,** Soil Science, University of California, Davis
- F **Flores Cáceres, Silverio,** Plant Pathology, Louisiana State University
- s **León Ochoa, Horacio,** Soil Science, Michigan State University
- s **Téliz Ortiz, Daniel,** Genetics & Plant Breeding, University of Nebraska
- F **Téliz Ortiz, Moisés,** Plant Pathology, University of Wisconsin

National University, Faculty of Veterinary Science, Mexico City
- F **Brambila, Sergio,** Poultry Husbandry, University of California, Davis
- S **Reta P., Gustavo,** Poultry Husbandry, Purdue University
- S **Rivera Cruz, Eduardo,** Veterinary Science, Iowa State University

NATIONAL REPUBLIC OF CHINA, TAIWAN

Chinese-American Joint Commission on Rural Reconstruction, Taipei
- F **Lee, Robert Chung Tao,** Veterinary Science, Cornell University

NICARAGUA

Ministry of Agriculture and Livestock, Managua
- S **Lizárraga Herrera, Joaquín Héctor,** Soil Science, North Carolina State College
- S **Villena Duchen, Willy,** Genetics & Plant Breeding, University of Nebraska

PAKISTAN

Ministry of Food and Agriculture, Karachi
- F **Hassan, Muhammad Amjad,** Soil Science, University of Illinois

PERU

Agrarian University, La Molina, Lima
- F **Grobman, Alexander,** Genetics & Plant Breeding, University of Nebraska
- S **Indacochea Pejovés, Luisa,** Library Science, North Carolina State College
- S **Manrique Chávez, Antonio,** Genetics & Plant Breeding, University of Nebraska
- S **Moreno, Ulises,** Botany, Cornell University
- S **Paulette del Campo, Miguel,** Agronomy, University of Nebraska
- S **Pimental, Hector Rafael,** Food Technology, Massachusetts Institute of Technology
- S **Rondón Olazaval, Mario,** Genetics & Plant Breeding, North Dakota State University
- S **Soikes, Raul S.,** Animal Nutrition, North Carolina State College
- S **Voysest Voysest, Oswaldo,** Genetics & Plant Breeding, University of California, Davis

Ministry of Agriculture, Cooperative Program of Agricultural and Livestock Research
- S **Arroyo Vergara, Julio Roger,** Experimental Statistics, North Carolina State College
- S **Christiansen Gonzalez, Jorge,** Genetics & Plant Breeding, Mexican Agricultural Program
- S **Dongo Denegri, Segundo,** Plant Pathology, Mexican Agricultural Program

National University of Engineering, Lima
- S **Tisnado, Alicia,** Library Science, Rutgers University

National University of San Marcos, Faculty of Veterinary Science, Lima
- F **Lombardi Lombardi, Max,** Veterinary Science, Cornell University
- S **Nuñez, Quiterio,** Veterinary Science, Iowa State University
- S **Orbezo Suárez, Germán,** Veterinary Science, Mexican Agricultural Program and Pennsylvania State University

PHILIPPINES

Bureau of Public Schools, Manila

F **Quirolgico, Delfín G.,** Economics & Rural Life, Stanford University

Bureau of Soils, Manila

S **Endriga, Barbara-Ann Gamboa (Mrs. Guillermo B.),** Agronomy, University of California, Berkeley

Central Luzon Agricultural College, Nueva Ecija

F **Abella y Aguilar, Pedro,** Agronomy, University of Florida

S **Mundo, Angelito D. del,** Plant Physiology, University of Missouri

International Rice Research Institute

S **Manalo, Lina D.,** Library Science, Rutgers University

Mindanao Agricultural College, Bukidnon

F **Zablan, Florendo Flores,** Economics & Rural Life, Cornell University

Philippine Atomic Energy Commission, Manila

F **Valencia, Iluminado G.,** Soil Science, University of Wisconsin

University of the Philippines

college of agriculture

F **Alfonso, Pablo J.,** Zoology, Colorado State University

S **Bernardo, Fernando Apelo,** Genetics & Plant Breeding, North Carolina State College

F **Bustrillos, Nena Rola,** Home Economics, Michigan State University

F **Cadiz, Teodoro G.,** Horticulture, Louisiana State University

F **Calora, Feliciano Banaag,** Entomology, Cornell University

F **De Padua, Dante B.,** Agricultural Engineering, Michigan State University

S **Divinagracia, Gil G.,** Plant Pathology, University of California, Davis

F **Eusebio, Jose A.,** Animal Husbandry, Iowa State University

F **Gabriel, Bernardo Panuncialman,** Entomology, University of California, Berkeley

F **Jamias, Juan Farolan,** Economics & Rural Life, Michigan State University

F **Lantican, Domingo M.,** Forestry, New York College of Forestry (Syracuse)

F **Madamba, Cesar Palting,** Nematology, North Carolina State College

F **Ramirez, Dolores Altoveros,** Genetics & Plant Breeding, Purdue University

F **San Juan, Mario O.,** Plant Pathology, University of Wisconsin

F **Sison, (Mrs.) Obdulia E. Fronda,** Economics & Rural Life, Cornell University

F **Tilo, Santiago Nanat,** Soil Science, University of Illinois

F **Valmayor, Ramon V.,** Agronomy, University of Florida

F **Vega, Marcos R.,** Plant Physiology, North Carolina State College

F **Yniguez, Amador D'Bayan,** Biometry, North Carolina State College

F **Zamora, Prescillano M.,** Botany, Cornell University

college of liberal arts

F **Juliano, Rogelio Ochoa,** Marine Resources, University of Michigan

POLAND

College of Agriculture, Cracow

F **Barbaro, Agnieszka (Mrs. Jerzy),** Plant Physiology, California Institute of Teçhnology, Pasadena

Ministry of Agriculture, Institute of Inland Water Fisheries, Olsztyn-Kortowo

F **Patalas, Kazimierz,** Fisheries, University of British Columbia, Vancouver, Canada, and University of Colorado

Ministry of Agriculture, Institute of Soil Science and Plant Cultivation, Pulawy

- F **Myskow, Wladyslaw,** Soil Science, Macaulay Institute for Soil Research, Aberdeen, Scotland

Ministry of Agriculture, Veterinary Research Institute, Pulawy

- F **Larski, Zdzislaw,** Animal Science, Wistar Institute
- F **Truszczynski, Marian,** Animal Science, Boston University

Polish Academy of Sciences, Poznan

- F **Nowacki, Edmund Kazimierz,** Genetics & Plant Breeding, Michigan State University

SUDAN

University of Khartoum

- S **Osman Mousa, Hussein Elsayed,** Genetics & Plant Breeding, University of Edinburgh, Scotland

THAILAND

Department of Agriculture, Bangkok

- F **Anuwat, Wattanapongsiri,** Entomology, University of Kansas

Kasetsart University, College of Agriculture, Bangkok

- S **Buangsuwon, Pairoj,** Plant Pathology, Oregon State University
- F **Chutima, (Mrs.) Krisna,** Chemistry, Purdue University
- S **Kanchanomai, Prachern,** Agronomy, Louisiana State University
- S **Kasetsuwan, Suwan,** Poultry Husbandry, Utah State University
- F **Khatikarn, Bunjird,** Horticulture, Utah State University
- S **Pongkao, Sawai,** Agronomy, University of Nebraska
- S **Poolsup, Maitri,** Agricultural Engineering, Utah State University
- S **Vachananda, Sookapracha,** Organic Chemistry, Michigan State University

UGANDA

Department of Veterinary Services and Animal Industry, Kampala

- S **Thornton, David Dillon,** Forestry, University of California, Berkeley

VENEZUELA

Ministry of Agriculture, Maracay

- F **Morillo Andrade, Francisco Jose,** Genetics & Animal Breeding, North Carolina State College

SOUTH VIETNAM

Ministry of Agriculture, Saigon

- S **Bui Van Tro,** Animal Husbandry, Cornell University
- S **Minh, Duong Van,** Agricultural Engineering, Cornell University
- S **Quan, Cao,** Economics & Rural Life, Cornell University
- S **Quyen, Ngo Van,** Entomology, Cornell University
- S **Tri, Bui Huu,** Soil Science, Cornell University
- S **Van, Nguyen Hoai,** Soil Science, Cornell University

Aid to Research and Teaching

UNITED STATES

California Institute of Technology, Pasadena: development of a program of research on the responses of plants to climate at the Earhart Laboratory for Plant Research; $90,000 for a three-year period.

Dr. J. G. Horsfall, director, Connecticut Agricultural Experiment Station, New Haven: to participate in scientific seminars, and to visit centers of agricultural research in India and Japan; $2,100.

Cornell University, New York State College of Agriculture, Ithaca:

> Development of a special orientation program for foreign graduate students; $50,000 for a five-year period;
>
> Dr. A. A. Johnson, acting head, Department of Plant Breeding; to attend the Food and Agriculture Organization of the United Nations technical meeting on Seed Production, Control, and Distribution held in Rome, Italy; $880.

North Carolina State College, Raleigh: development of studies in cytogenetics; $2,000.

Ohio State University, Columbus:

> Research in plant pathology at the College of Agriculture and Home Economics under the direction of Dr. C. C. Allison; $10,000;
>
> Continued research on the fungal synthesis of cheap microbial protein under the direction of Dr. W. D. Gray, Department of Botany and Plant Pathology, College of Agriculture and Home Economics; $10,000.

Pennsylvania State University, University Park: to send four pomology specialists to assist in the deciduous tree fruit research at the National Institute of Agricultural and Livestock Technology, Buenos Aires, Argentina; $5,800.

Texas Agricultural and Mechanical College System, College Station: research on fundamental problems of nutrition in ruminant animals, under the direction of Dr. William C. Ellis, Department of Animal Husbandry; $62,850 for a five-year period.

Texas Research Foundation, Renner: preparation and publication of a monograph by Dr. Donovan S. Correll on cultivated potatoes and their wild relatives; $10,000 for a one-year period.

Texas Technological College Foundation, Lubbock: to enable Dr. B. L. Allen, professor of soils, to undertake a thin section study of soils collected in the Papaloapan Basin in Mexico; $1,000.

Library of the United States Department of Agriculture, Washington, D. C.: to prepare a subject heading guide for use in agricultural libraries; $35,000 for a two-year period.

University of Alaska, Agricultural Experiment Station, College: research on potato diseases at the Agricultural College in Vollebekk, Norway, by Dr. Charles E. Logsdon; $10,000 for a two-year period.

University of California:

Berkeley:

> Dr. Henry Rapoport, professor of chemistry; to serve as a research consultant in natural products at the Institute of Agricultural Chemistry, Ministry of Agriculture, Rio de Janeiro, Brazil; $6,106;
>
> Dr. William C. Snyder, vice-chairman, Department of Plant Pathology, College of Agriculture; to confer with plant pathologists in Hawaii, Japan, and Australia; $4,070.

Riverside:

> Research by Dr. Paul Debach, entomologist, Citrus Experiment Station, College of Agricul-

ture, at the Institute of Ecology and Agricultural Experimentation, Ministry of Agriculture, Rio de Janeiro, Brazil; $9,700.

University of Massachusetts, Amherst: research on the effects of certain insecticides upon insects and wildlife, by the College of Agriculture; $3,000.

University of Minnesota, St. Paul:

Genetic studies of Ethiopian hard wheats at the Institute of Agriculture; $7,500;

Dr. Clyde M. Christensen, professor of plant pathology, Department of Plant Pathology, Institute of Agriculture; to attend meetings of the Association of Cereal Research in Germany, the International Association of Cereal Chemistry in Austria, and to visit research centers concerned with grain storage problems in England and Denmark; $2,500;

Dr. E. H. Rinke, professor, Department of Agronomy and Plant Genetics, Institute of Agriculture; to attend a conference of the European and Mediterranean Maize Group in Rome, Italy; $925.

University of Nebraska, Lincoln: development of a research program in maize genetics in the Department of Agronomy, College of Agriculture; $60,000 for a five-year period.

University of Wisconsin, Madison:

Research on the application of solar energy to agricultural problems, by the Solar Energy Laboratory; $135,000 for a three-year period;

Dr. A. J. Riker, professor of plant pathology, College of Agriculture; to confer with forest pathology specialists in the United States and Latin America; $4,550;

Dr. R. E. Nichols, professor of veterinary science, Department of Veterinary Science, College of Agriculture; to confer with agricultural and veterinary scientists in Africa; $3,440;

Dr. Robert W. Hougas, associate professor of genetics, and on the staff of the Agricultural Research Service, United States Department of Agriculture, Madison, Wisconsin; to visit potato improvement programs in Peru, Colombia, and Mexico; $1,900.

University of Wyoming, Laramie: a survey of browse range vegetation in Mexico, by Dr. Alan A. Beetle, professor of range management; $3,000.

WEST INDIES

JAMAICA

Institute of Jamaica, Kingston: herbarium cabinets for the Department of Botany; $7,600.

TRINIDAD

University of the West Indies, St. Augustine:

To invite Dr. Dunstan Skilbeck, principal, Wye College, University of London, England, to serve as a special consultant on problems of organization and programs at the Faculty of Agriculture; $3,000;

Dr. Peter N. Wilson, professor of agriculture; to observe recent developments in teaching methods and research in animal husbandry at agricultural education and research institutions in the United States, England, and Latin America; $1,620;

Philip M. Sherlock, vice-principal; to visit The Rockefeller Foundation cooperative agricultural programs in Mexico and Colombia; $1,270;

Dennis Frederick Osbourn, lecturer, Department of Agriculture; to visit grassland and crop husbandry centers in Puerto Rico, Jamaica, the United States, and Mexico; $900.

LATIN AMERICA

ARGENTINA

Ing. Domingo R. Pasquale, director, Balcarce Experiment Station, National Institute of Livestock Technology, Buenos Aires: to visit potato research programs in Colombia and Mexico, and to attend the Potato Association of America meetings in Madison, Wisconsin; $1,900.

BRAZIL

Faculty of Philosophy, Sciences and Letters of Rio Claro: studies of bee genetics, management, and behavior, by Virgilio de Portugal Araujo, Department of Agriculture and Forests, Luso, Angola; $10,000.

Ministry of Agriculture, Rio de Janeiro:

Equipment and supplies for the Institute of Agricultural Chemistry; $10,000;

Eng. Lincoln Monteiro Rodrigues, agronomist engineer; to undertake advanced training at the University of Wisconsin, Madison; $2,850.

São Paulo State Secretariat of Agriculture:

Research equipment, greenhouses, and publications for the library, Institute of Agronomy, Campinas; $140,000;

Field and laboratory equipment and materials for the Department of Animal Production, Animal Nutrition Research Center, Nova Odessa; $75,000 for a three-year period;

Dr. Geraldo Leme da Rocha, head, Department of Animal Production, Animal Nutrition Research Center, Nova Odessa; to visit research centers specializing in pasture and animal feeding investigation in Latin America and the United States, and to visit The Rockefeller Foundation operations in Chile, Colombia, and Mexico; $3,120.

Luiz de Queiroz College of Agriculture, University of São Paulo, Piracicaba; equipment for use by the Institute of Genetics in a maize improvement program; $10,000.

CHILE

Dr. Ruy Barbosa, dean, School of Agronomy, University of Chile, Santiago: to visit centers of agricultural education and research in Costa Rica, Honduras, Mexico, and the United States; $1,750.

University of Concepción:

Field and laboratory equipment, a greenhouse, and library materials for the Faculty of Agronomy, Chillán; $85,000 for a two-year period;

Equipment for a systematic and ecological inventory of the country's plant resources, to be conducted by Professor M. Ricardi S., Biological Institute; $3,000.

COSTA RICA

Inter-American Institute of Agricultural Sciences:

San José:

Dr. Guy W. Adriance, Agricultural and Mechanical College of Texas, Dr. Walter Reuther, University of California, and Dr. Damon Boynton, Cornell University; to participate in a symposium on Temperate Zone Fruits in the Tropical Highlands held in Antigua, Guatemala; $1,500.

Turrialba:

Participation in a teaching and research program on maize improvement of the Graduate School, National School of Agriculture, Chapingo, Mexico, by Dr. Mario Gutiérrez G., plant geneticist; $10,000;

Development of a course in science reference and bibliography for Latin American librarians; $7,500;

To invite deans from colleges of agriculture in Latin America to attend the Second Conference on Agricultural Higher Education held in Medellín, Colombia; $7,500.

ECUADOR

Ing. Guillermo Merino Dominguez, professor of agronomy, Faculty of Agricultural Engineering, Central University, Quito: to study recent research developments in corn improvement in Mexico and Guatemala; $1,300.

GUATEMALA

National Agricultural Institute, Guatemala City: field and laboratory equipment for three regional centers engaged in research and extension programs; $40,000 for a three-year period.

University of San Carlos, Guatemala City:

Development of the Faculties of Veterinary Medicine and Agronomy and of a new Institute of Animal Husbandry; $300,000 for a four-year period;

Dr. Juan de Dios Moscoso Najarro, instructor in animal anatomy, Faculty of Veterinary Medicine and Zootechnics; to study recent developments in research and education in animal anatomy at departments of anatomy in the United States; $1,500.

HONDURAS

Office of Natural Resources, Secretariat of State, Tegucigalpa: equipment for the Cooperative Maize Improvement Project in Central America; $2,600.

MEXICO

Pablo Velasquez, librarian, National Institute of Agricultural Research, Mexico City: to attend a meeting of Latin American agricultural librarians at the Inter-American School of Librarianship, University of Antioquia, Medellín, Colombia; $880.

National Institute of Nutrition, Mexico City: research in biochemistry and nutrition; $42,000 for a two-year period.*

National School of Agriculture, Chapingo:

> Development of the Graduate School; $110,000;
>
> Ing. Diego de la Peña Garcia, lecturer, and technical advisor to the Secretary of Public Health, Government of Mexico; to visit mushroom producing and research centers in the United States; $1,350;
>
> Professor Efraín Hernández Xolocotzi, Graduate School; to assist in developing ecological studies of natural grasslands at the School of Agriculture and Veterinary Science, University of Rio Grande do Sul, Pôrto Alegre, Brazil; $1,200.

Dr. Manuel H. Sarvide A., head, Department of Pathological Anatomy, National School of Veterinary Medicine, National University of Mexico, Mexico City: to visit schools of veterinary medicine in Latin America; $3,300.

University of Coahuila, Saltillo: expenses of two representatives of the Antonio Narro College of Agriculture in connection with their attendance at the Second Conference on Agricultural Higher Education held in Medellín, Colombia; $2,000.

Expenses in connection with the organization of the Fourth Pan-American Congress of Veterinary Medicine and Animal Husbandry, to be held in Mexico during November, 1962; $5,000.

PERU

Agrarian University, La Molina, Lima:

> Ing. Antonio Bacigalupo, head, Institute of Research and Advanced Studies; to observe organizational patterns, program and curriculum planning, administrative procedures, and study progress in animal nutrition research at research and graduate training centers in Colombia, Central America, Mexico, and the United States; $2,150;
>
> Dr. Ferruccio Accame, dean, Faculty of Zootechnology; to attend the American Dairy Science Association meetings held in College Park, Maryland; $1,125;
>
> Dr. Octavio Velarde, dean, Faculty of Agronomy; to attend the Second Conference on Agricultural Higher Education, Medellín, Colombia, and to visit the Colombian Agricultural Program; $900.

Ministry of Agriculture, Lima:

> Ing. Benjamín Quijandría, assistant director, Agricultural Research and Development Service, and Mrs. Quijandría; to study research, extension, and teaching at experiment stations and research centers in Latin America and the United States; $4,410;
>
> Ing. Abelardo Baracco Gandolfo, technical director, Agricultural Research and Development Service; to visit agricultural and livestock development programs in Colombia, Costa Rica, Mexico, and the United States; $2,250.

University of San Marcos, Lima: equipment for the radiobiology laboratory and housing for foreign students and visiting professors: $25,000 for a three-year period.

EUROPE

POLAND

Central Agricultural Library, Warsaw:

> Andrzej Pakosz, Documentation Center; to observe the services at the Library of the United States Department of Agriculture, Washington, D.C., and at other libraries in the United States; $2,880;
>
> Mrs. Irena Wielburska, librarian; to visit the Library of the Agricultural College of Norway,

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* Grant made cooperatively between the program in Agricultural Sciences and other programs of The Rockefeller Foundation.

Vollebekk, to study and cooperate in the Scandia Plan, and to visit agricultural libraries in the Scandinavian countries; $1,300.

Bernard Filutowicz, director, Bureau for Agricultural Institutes, Ministry of Agriculture, Warsaw: to visit centers of agricultural research and of extension in the United States, England, and Germany; $3,240.

Institute of Plant Genetics, Polish Academy of Sciences, Poznan: chemical supplies for research, under the direction of Professor S. Barbacki; $1,500.

SWEDEN

Miss Margarete Akesson, director, Royal Veterinary College Library, Stockholm: to visit libraries in the United States; $2,995.

Swedish Seed Association, Svalöf: equipment for a plant disease research program; $10,000.

University of Lund: research on hybrids in the Institute of Genetics; $40,000 for a three-year period.*

UNITED KINGDOM

Commonwealth Agricultural Bureau, Farnham Royal, England: to purchase sets of series of abstract and review journals for distribution to selected agricultural libraries in Latin America, India, and Japan; $26,000.

Dr. R. S. Pitcher, nematologist, East Malling Research Station, Maidstone, Kent: to confer with nematologists in the United States; $2,590.

Dr. E. B. Worthington, Deputy Director General (Scientific), Nature Conservancy, London: to attend the Eighth National Conference of the United States National Commission for UNESCO in Boston, Massachusetts, and to confer with soil conservation specialists in the United States: $1,425.

Rothamsted Experimental Station, Harpenden:

Dr. Derek H. Lapwood, senior scientific officer, Department of Plant Pathology; to visit the Inter-American Potato Improvement Project in Mexico and selected potato improvement centers in the United States and Canada; $5,800;

Dr. Phillip H. Gregory, head, Department of Plant Pathology; to visit centers of plant pathology research in the United States; $2,410.

Dr. R. L. Wain, professor of agricultural chemistry, Wye College, University of London, Kent: to visit centers of plant science research in the United States; $2,225.

AFRICA

Expenses of a conference on the organization of scientific research in Africa, held at the Villa Serbelloni, Bellagio, Italy; $17,000.*

ETHIOPIA

Imperial Ethiopian College of Agricultural and Mechanical Arts, Dire Dawa: development of a program of special lectures and seminars in the arts and sciences; $8,000.

GHANA

Professor K. Twum-Barima, head, School of Agriculture, Kwame Nkrumah University of Science and Technology, formerly the Kumasi College of Technology: to attend the Eighth National Conference of the United States National Commission for UNESCO in Boston, Massachusetts, and to confer with agricultural educators in the United States, Puerto Rico, and Trinidad; $3,280.

Frederick Maxwell Amfo Sackey, poultry development officer, Division of Agriculture, Pokoase, Ministry of Agriculture, Accra: to visit centers of research in poultry science in the United States; $1,340.

KENYA

East African Common Services Organization, East African Agriculture and Forestry Research Organization, Kikuyu:

Expenses of a mobile animal research laboratory; $20,000;

Spectrographic equipment; $7,500.

Egerton College, Njoro:

Laboratory equipment; $10,000;

M. A. Barrett, principal; to confer with specialists in agricultural education and extension in

Italy, the United States, Puerto Rico, Ghana, and Nigeria; $3,725.

Ministry of Agriculture, Animal Husbandry, and Water Resources:

Department of Agriculture, Nairobi; establishment of a biological control station; $10,000;

Veterinary Research Laboratory, Department of Veterinary Services, Kabete; purchase of publications for the central and field station libraries; $9,000;

Richard H. Bennison, agricultural research officer, Department of Agriculture, Machakos; to visit research stations in the United States dealing with agricultural problems of semiarid regions; $3,590.

MALI

Federal Animal Husbandry Research Center, Sotuba: equipment for an artificial insemination program; $5,000.

NIGER

Kolo Agronomy Station: field equipment; $5,000.

NIGERIA

Claude C. Cheysson, Secretary General, Commission for Technical Cooperation in Africa South of the Sahara, Lagos: to attend the Eighth National Conference of the United States National Commission for UNESCO in Boston, Massachusetts; $1,900.

Nigeria Secondary School, Nnewi, Eastern Region: laboratory equipment for science courses; $5,000.

Northern Region Experiment Station, Samaru: development of a cereal research program; $345,000 for a three-year period.

University College, Ibadan:

Research and teaching in rural pediatrics, and extension of studies of agricultural production, under the direction of Dr. W. R. F. Collis, Institute of Child Health; 64,300 Nigerian pounds (about $182,000) through June, 1965;*

Dr. A. N. A. Modebe, lecturer in animal husbandry, Faculty of Agriculture; to visit centers of research on poultry and swine production in the United States, Ireland, and Denmark; $4,315;

Dr. R. J. McIlroy, professor of agriculture; to visit centers of agricultural research and education in the United States; $3,800.

RHODESIA AND NYASALAND

Chibero College of Agriculture: books and visual aid equipment; $7,500.

Henderson Research Station, Mazoe: research on farming systems in selected areas of Africa; $5,000 for a two-year period.

Professor A. G. Davis, Faculty of Science, University College of Rhodesia and Nyasaland, Salisbury: to visit centers of agricultural extension and alfalfa research in the United States, Mexico, Colombia, and Canada; $8,550.

TANGANYIKA

Purchase of reference books for the Regional and District Agricultural Headquarters, Ministry of Agriculture, Dar es Salaam; $7,500.

UGANDA

Makerere University College, Faculty of Agriculture, Kampala:

Expenses in connection with the teaching and research program; $60,000;

Professor Fergus Wilson, dean; to observe research and agricultural extension work at agricultural colleges in the United States; $4,980.

UPPER VOLTA

Saria Agricultural Station: development of a regional sorghum improvement program; $10,000 for a two-year period.

MIDDLE EAST

ISRAEL

Hebrew University, Jerusalem:

Research on ancient agricultural systems in the Negev, under the direction of Professor Michael Evenari, Department of Botany; $108,000 through June, 1965;

Dr. Y. Henis, instructor in agricultural microbiology, Department of Bacteriology, Faculty of Agriculture, Rehovot; to visit research and teaching centers concerned with applied and basic studies in soil and agricultural microbiology in Europe, Canada, and the United States; $4,900.

Arye Sive, director, Cold Storage Research Laboratory, Israel Fruit Growers Association, Kfar Blum, Upper Galilee: to confer with agricultural scientists in the United States, the United Kingdom, and Europe; $4,150.

SOUTH ASIA

INDIA

Dr. S. Krishnamurthi, dean and additional director of agriculture, Agricultural College and Research Institute, Coimbatore: to study research and education programs at selected agricultural colleges and research institutions in the Near East, Europe, the United States, Japan, the Philippines, and the Far East; $5,700.

Dr. C. O. Das, head, Chemistry Department, Allahabad Agricultural Institute: to study dairy chemistry, statistical analysis, and the latest techniques in dairy science in Europe, the United States, Japan, and the Philippines; $5,590.

Indian Agricultural Research Institute, New Delhi: equipment for the library; $45,000 through October, 1964.

Dr. K. L. Narasimham, head, Directorate of Agriculture and Animal Husbandry, Government of Sikkim, Gangtok: to study temperate and citrus fruit production, canning industries, orchids, and floriculture at agricultural research stations in Japan, Italy, Hawaii, and the continental United States; $3,550.

Dr. M. J. Thirumalachar, chief of research, Hindustan Antibiotics Research Centre, Pimpri, Poona: to plan advanced work with antibiotics in plant and human diseases at mycological and medical microbiological centers in the United States; $1,700.

Sri Avinashilingam Home Science College, Coimbatore: textbooks and other library materials in the field of home science; $5,000.

Uttar Pradesh Agricultural University, Rudrapur:

> Development of an Agricultural Experiment Station on lands of the university; $240,000 for a five-year period;
>
> Kenneth Anthony Patrick Stevenson, vice-chancellor; to study administrative patterns and procedures for research, education, and extension at various universities and land-grant colleges in the Near East, Europe, the United States, and the Far East; $7,600.

THAILAND

Seri Emasiri, chief, Division of Animal Nutrition and Forage Crops, Department of Livestock Development, Bangkok: to visit various institutions, organizations, farms, and commercial feed mills in Europe, the United States, Latin America, New Zealand, Australia, the Philippines, and Malaya; $4,775.

Samai Charoenrath, head, Division of Research and Experiment Stations, Department of Agriculture, Bangkok: to study recent developments in agricultural research at experiment stations in Latin America and the United States; $5,950.

Kasetsart University, Bangkok:

> Equipment and supplies for the Thai cooperative corn improvement project; $16,000 for a two-year period;
>
> Anchern Chompoophot, head, Department of Horticulture; to study recent developments in horticultural research and education at institutions in Southeast Asia; $4,000.

FAR EAST

AUSTRALIA

David John David, senior research officer, Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Canberra: to study current techniques in X-ray fluorescence, arc, spark, and flame emission, and in atomic absorption spectroscopy at agricultural research laboratories in the United States; $1,925.

Mr. C. D. Blake, plant pathologist, New South Wales Department of Agriculture, Rydalmere: to observe recent developments in nematology at research centers in the United States; $725.

University of Adelaide, Waite Agricultural Institute:

Equipment for research in the Department of Plant Pathology; $6,216;

Dr. Bruce Johnson, senior lecturer in entomology; to visit entomology centers in the United States and Canada; $1,825.

HONG KONG

Dr. H. Stenton, professor of botany, Department of Botany, University of Hong Kong: to review work in soil microbiology at university departments of botany and agriculture and at government agricultural experiment stations in the United States and Canada; $900.

INDONESIA

University of Indonesia, Bogor:

Dr. Jannes Humuntal Hutasoit, senior lecturer and head, Department of Animal Nutrition, Faculty of Veterinary Science and Animal Husbandry; to visit animal husbandry and nutrition centers in Western Europe, the United States, and Japan; $6,400;

Dr. Gerardus Sutardi Mangundojo, head, Department of Entomology, Faculty of Agriculture; to study recent developments in entomology and nematology research at institutions in Japan, the United States, Canada, Western Europe, and South Asia; $6,135.

JAPAN

Hokkaido University, Sapporo: continued research on forage crop production in the Faculty of Agriculture; $28,700 for a three-year period.

Dr. Takumi Tsuchiya, head, Division of Cytogenetics of Cereals, Kihara Institute for Biological Research, Yokohama: to observe recent developments in cytogenetics, plant breeding, and radiation genetics at research centers in the United States and Canada; $3,750.

Kyoto University, Faculty of Agriculture:

Further studies of the genetics of wheat; $37,700 for a three-year period;

Dr. Yoshimasa Nishikawa; to observe methods of artificial insemination and animal reproduction at research centers in the United States and Canada; $3,700.

Dr. Tsutomu Shioya, professor of forest economics and policy, Kyushu University, Fukuoka: to observe pasture and forest management and land policy at institutions in Western Europe; $4,800.

National Institute of Genetics, Misima: continued studies of the origin of cultivated rice; $60,000 for a three-year period.

Tohoku University, Faculty of Agriculture, Sendai:

Research on the effective use of upland soils in Japan; $61,000 for a three-year period;

Dr. Kanoe Sato, associate professor of crop science; to visit animal nutrition and forage crop improvement centers in the United States and Colombia; $3,000;

Dr. Tsuneyuki Tsuda, associate professor of crop science; to visit animal nutrition and forage crop improvement centers in the United States and Colombia; $3,000.

University of Tokyo:

Development of the university library; $36,000;*

Professor Mitsuo Yokoyama, professor of landscape architecture, Faculty of Agriculture; to visit landscape architecture centers and botanical gardens in the United States and Europe; $4,200;

Professor Taizo Inokuma, Department of Forestry, Faculty of Agriculture; to visit libraries and institutions in the United States; $3,300;

Daitsu Satake, secretary-general, Faculty of Agriculture; to visit libraries and institutions in the United States; $3,300.

PHILIPPINES

Bureau of Plant Industry, Department of Agriculture and National Resources, Manila: technical books for the Guinobatan Experiment Station; $1,500.

University of the Philippines:

Laguna:

Dr. G. F. Saguiguit, director, College of Agriculture; to study undergraduate and graduate programs and systems of national examination at agricultural institutions in Europe, the United States, and the Far East, and to attend the International Conference on Agricultural Teaching in Zurich, Switzerland; $5,140;

Mrs. Juanita C. Ranit, librarian, College of Forestry; to visit forestry libraries in the United States; $2,540.

Los Baños:

To invite teams of agricultural consultants to visit the College of Agriculture; $25,000 for a three-year period;

Engracio Basio, chief librarian, College of Agriculture; to visit libraries and institutions in South and Southeast Asia; $4,040.

Quezon City:

Books for the library of the College of Home Economics; $9,000 for a two-year period.

Xavier University, Cagayan de Oro City: development of a Soils Testing Laboratory in the College of Agriculture; $8,410 for a two-year period.

Publications 1961-1962

Mexican Agricultural Program

CORN AND SORGHUM

Miranda Jaimes, Odón. El carbón de la espiga del maíz en el Bajío. *Agricultura Técnica en México,* No. 12, Winter, 1961–1962.

CEREALS

Paredes T., Andrés, Manuel Pardo G., Espartaco Barletti, and Damián Correu Toledo. Recomendaciones para el cultivo del arroz en el Estado de Morelos. *Circular El Horno No. 9*, November, 1961.

Professional staff of the Cereals Department. Recomendaciones para el cultivo de trigo en la Costa Noroeste del Pacífico. *Boletín de Extensión Agrícola No. 347*, September, 1961.

Professional staff of the Cereals Department. Recomendaciones para el cultivo de trigo en la región del Bajío. *Boletín de Extensión Agrícola No. 348*, September, 1961.

Professional staff of the Cereals Department. Recomendaciones para el cultivo de trigo en los valles altos de la Mesa Central y del Norte de México. *Boletín de Extensión Agrícola No. 349*, September, 1961.

Professional staff of the Cereals Department. Recomendaciones para el cultivo de trigo en La Comarca Lagunera. *Boletín de Extensión Agrícola No. 350*, September, 1961.

Professional staff of the Cereals Department. La cebada produce bien en el Bajío. Recomendaciones, Ciclo 1961–1962. *Boletín de Extensión Agrícola No. 351*, October, 1961.

Professional staff of the Cereals Department. La cebada produce bien en los valles altos. Recomendaciones, Ciclo verano, 1962. *Boletín de Extensión Agrícola No. 352*, November, 1961.

Riojas, Enrique and Joel Rodríguez V. Recomendaciones para el cultivo de la cebada en el Noroeste. *Boletín de Extensión Agrícola No. 353*, January, 1962.

BEANS AND SOYBEANS

Cárdenas R., Francisco. La densidad de siembra influye en el rendimiento del frijol. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Crispín M., Alfonso and R. Grogan. Seed transmission of bean mosaic viruses. *Phytopathology*, 51:452–456, 1961.

Crispín M., Alfonso and Francisco Cárdenas R. Aumente su producción de frijol. *Boletín de Extensión Agrícola No. 354*, revised as of February, 1962.

Crispín M., Alfonso. Recomendaciones para el cultivo de la soya en Aguascalientes. *Circular CIAB No. 1*, April, 1962.

Crispín M., Alfonso and S. Dongo. New physiologic races of bean rust *Uromyces phaseoli-typica* from Mexico. *Plant Disease Reporter*, 46:411–413, 1962.

Guevara Calderón, José. Variedades de frijol resistentes a las plagas. *Boletín Técnico de la Sociedad Agronómica Mexicana*, Vol. II, No. 6, 1960.

POTATOES

Cervantes R., Javier and R. H. Larson. Alfalfa mosaic virus in relation to tuber necrosis in the potato variety Red La Soda. *University of Wisconsin Research Bulletin 229*, July, 1961.

Delgado Sánchez, Santiago and Ramón Rubio Valle. Recomendaciones para el cultivo de la papa en el Valle de Toluca. *Circular CIB No. 1*, April, 1962.

Fernández B., Jesús and John S. Niederhauser. El cultivo de la papa en el Bajío. *Boletín de Extensión Agrícola No. 351*, September, 1961.

HORTICULTURE

Acosta Lara, Luis P. La cenicilla o mildeu polvoriento de la fresa. *Novedades Hortícolas*, Vol. VI, No. 4, October–December, 1961.

Alvarez Luna, Eduardo. El cultivo del chile en el huerto familiar. *Novedades Hortícolas*, Vol. VII, No. 1, January–March, 1962.

Alvarez Luna, Eduardo and Martín Garatuza Rodríguez. Culiacán 1, una nueva variedad de jitomate para Sinaloa. *Folleto de Divulgación No. 30*, November, 1961.

Alvarez Luna, Eduardo and Hilda Mendoza. *Calendario del huerto familiar para la región de el Bajío*. 1962.

Andrade Arias, Enrique. Los huertos familiares en el Estado de México. *Novedades Hortícolas*, Vol. VI, No. 2, April–June, 1961.

Andrade Arias, Enrique and Eduardo Alvarez Luna. El cultivo de la acelga y la espinaca. *Novedades Hortícolas*, Vol. VI, No. 3, July–September, 1961.

Hernández Bravo, Guillermo. El cultivo del jitomate. *Novedades Hortícolas*, Vol. VI, No. 3, July–September, 1961.

Hernández Bravo, Guillermo. Plagas y enfermedades del jitomate. *Novedades Hortícolas*, Vol VI, No. 4, October–December, 1961.

Laborde C., José A. El cultivo del huauzontle. *Novedades Hortícolas*, Vol. VII, No. 1, January–March, 1962.

Lara, Luis. La fresa en el huerto familiar. *Novedades Hortícolas*, Vol. VI, No. 2, April–June, 1961.

Mendoza V., Hilda. Cuatro formas de preparar la calabaza. *Novedades Hortícolas*, Vol. VI, No. 2, April–June, 1961.

Mendoza V., Hilda. Cuatro recetas para cocinar zanahoria. *Novedades Hortícolas*, Vol. VI, No. 3, July–September, 1961.

Mendoza V., Hilda. Acelgas y espinacas en su cocina. *Novedades Hortícolas*, Vol. VI, No. 4, October–December, 1961.

Mendoza V., Hilda. Las ensaladas. *Novedades Hortícolas*, Vol. VII, No. 1, January–March, 1962.

Muñoz F., Ignacio. Descripción de variedades de las principales especies hortícolas. *Novedades Hortícolas*, Vol. VII, No. 1, January–March, 1962.

Muñoz F., Ignacio. Efecto de la fecha de siembra sobre el rendimiento y calidad de la semilla de lechuga. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

FORAGE GRASSES

Hernández X., Efraím, Ramón Claverán, and Fiacro Martínez M. Estudios cuantitativos de los pastizales de Chihuahua y Zacatecas. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

SOIL FERTILITY

Laird, Reggie J. Discusión general sobre los experimentos de fertilizantes realizados en Centro América en 1960. *Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz*, February, 1961.

Navarro, Ignacio, Antonio Turrent F., R. J. Laird, and Enrique Ortega T. Problemas de fertilidad en algunos suelos de la Sierra Tarasca. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Núñez Escobar, Roberto and Samuel Aguilar Yépez. La fertilización del trigo en el Valle del Yaqui. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Rosales G., Arnulfo, Enrique Ortega T., and R. J. Laird. Respuesta del maíz de temporal a los fertilizantes en el Sureste del Valle de México. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

ENTOMOLOGY

Guevara Calderón, José. El combate del picudo del ejote mediante la combinación de variedades resistentes e insecticidas. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Ramírez Genel, Marcos. Dos nuevos protectores de granos para zonas templadas y tropicales. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Wilbur, Donald A., Rodolfo Quintana, and William R. Young. Efectos de la altitud sobre unos insectos y el daño que causan al grano almacenado. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Young, W. R., Daniel Candia Z., D. Barnes, and D. L. Smith. Almacenamiento de maíz en el trópico bajo grados diferentes de humedad. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Young, W. R. and Daniel Candia Z. Biología y control de la "Doradilla" en el Campo Cotaxtla, Ver. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Papers Presented

Ortega, Alejandro. Plagas insectiles del maíz. Fifth meeting of the Inter-American Society of Agricultural Scientists, Buenos Aires, Argentina, November, 1961.

Ortega, Alejandro. Plagas del frijol en México. Fifth meeting of the Inter-American Society of

Agricultural Scientists, Buenos Aires, Argentina, November, 1961.

PLANT PATHOLOGY

Fuentes Fuentes, Santiago and Ma. de Lourdes de la Isla. Una enfermedad desconocida del maíz, el "diente de caballo." *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

León Gallegos, Héctor M. and Ignacio Muñoz Flores. Enfermedad de la sandía. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

POULTRY

Brambila, S. and J. A. Pino. El valor nutritivo del pulido de arroz para aves de corral. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

Cuca, Manuel and J. A. Pino. Combata los parásitos externos de sus aves. *Circular El Horno No. 8*, August, 1961.

Daniels, Ricardo. Alimentación de pavos criados en pastoreo y en confinamiento. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

ANIMAL NUTRITION

Hagen, Daniel D., Ned S. Raun, and Salvador Valadez. El uso de pasta de cártamo y harinolina, como fuentes de proteínas para el ganado. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

BIOMETRY

Rojas, Basilio A., Carlos Meza Romero, and José F. Garcés. El análisis de látices con equipo electromecánico de tarjetas perforadas. *Agricultura Técnica en México*, No. 12, Winter, 1961–1962.

AGRICULTURAL ECONOMICS

Freebairn, Donald K. Metodología de la investigación en economía agrícola. *Escuela Nacional de Agricultura (Chapingo) Folleto Técnico No. 2*, September, 1961.

AGRICULTURAL INFORMATION

Gutiérrez Jiménez, Mario. La preparación del manuscrito para una revista científica agrícola. *Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz*, February, 1961.

COLOMBIAN AGRICULTURAL PROGRAM

PASTURE AND FORAGE CROPS

Chaverra, Hernán, Agathon Wieczorek P., Alfonso Bastidas R., and Loy V. Crowder. Mezclas de cereales y pastos. *Boletín de Divulgación No. 12*, 1962.

Crowder Loy V., Rodrigo Ramírez, and Hernán Chaverra. Performance of temperate zone pasture species within tropical boundaries, as represented by Colombia. *Agronomy Journal*, 53:229–232, 1961.

Crowder, Loy V., Luis E. Castiblanco, and Jaime Vanegas. La producción de alfalfa en Colombia. XII. Métodos y densidades de siembra. *Agricultura Tropical*, XVII:541–556, 1961.

Echeverri, Silvio and Loy V. Crowder. Producción de gramíneas y leguminosas en Colombia. IV. Estudio de variedades y mejoramiento del ryegrass. *Agricultura Tropical*, XVIII:13–23, 1962.

Ramírez, Rodrigo, Loy V. Crowder, and Benedicto Acauan. Vigor de las plántulas de gramíneas y leguminosas cultivadas en los climas fríos de Colombia. *Agricultura Tropical*, XVII:445–459, 1961.

Silva, José V. and Loy V. Crowder. Producción de gramíneas y leguminosas en Colombia. III. Estudio de variedades de trébol egipcio. *Agricultura Tropical*, XVII:257–263, 1961.

SOIL SCIENCE

Gómez, Jairo A., Carlostadio Sánchez, and Manuel Rodríguez. Influencia de algunas labores de cultivos en el rendimiento del maíz. *Agricultura Tropical*, XVII:385–396, 1961.

PLANT PATHOLOGY

Barriga, Rodolfo O. Tratamiento de semilla de maíz con fungicidas y su almacenamiento en clima caliente húmedo. *Agricultura Tropical*, XVII:597–614, 1961.

Barriga, Rodolfo O., H. David Thurston, and Lee E. Heidrick. Ciclos de aspersion para el control de la "gota" de la papa. *Agricultura Tropical*, XVII:617–623, 1961.

Castaño, J. J. La mancha pardo-púrpura del pasto elefante. *Agricultura Tropical*, XVII:272–277, 1961.

Castaño, J. J. Nuevos aspectos en la investigación de la gomosis de pastos micay e Imperial. *Agricultura Tropical*, XVII:531–541, 1961.

Gálvez, Guillermo E., H. David Thurston, and Peter R. Jennings. Host range and insect transmission of the hoja blanca disease of rice. *Plant Disease Reporter*, 45:949–953, 1961.

Gálvez, Guillermo E. and H. David Thurston. Ratoon stunting disease of sugarcane in Colombia. *Plant Disease Reporter*, 45:954–956, 1961.

Gálvez, Guillermo E., H. David Thurston, and Peter R. Jennings. Hospedantes e insectos transmisores de la enfermedad hoja blanca del arroz. *Agricultura Tropical*, XVIII:138–150, 1962.

Thurston, H. David. The relative survival ability of races of *Phytophthora infestans* in mixtures. *Phytopathology*, 51:748–755, 1961.

Thurston, H. David, Lee E. Heidrick, and Julia Guzmán. Partial resistance to *Phytophthora infestans* (Mont.) de Bary within the Colección Central Colombiana. *American Potato Journal*, 39:63–69, 1962.

INDIAN AGRICULTURAL PROGRAM

AGRICULTURAL EDUCATION

Cummings, R. W. Presidential address. Second Annual Session of Madras Academy of Agricultural Sciences, Coimbatore, December 22, 1961.

MAIZE

Sprague, E. W., N. L. Dhawan, and R. L. Paliwal. Hybrid maize and its cultivation. *Indian Farming*, April, 1962.

Progress Report of the Coordinated Maize Breeding Scheme, 1961.

SEED PRODUCTION

Freeman, W. H. and S. M. Sikka. The seed production program for kharif, 1962. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Hagan, R. M. Irrigation and drainage practices for hybrid maize seed production. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Professional staff of Coordinated Maize Breeding Scheme. Nitrogen-phosphorus-potassium trial. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Professional staff of Coordinated Maize Breeding Scheme. A discussion of the advanced trials conducted in 1961. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Sahs, Warren W. Harvesting, drying and processing maize seed. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Sikka, S. M. and W. H. Freeman. The Seed Corporation program. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Traywick, J. D. and H. M. Jones. Equipment for seed production and processing. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

Young, W. R. Suggestions for insect control in maize. *Proceedings of the Maize Seed Producers' Conference, Part I*, New Delhi, February 5–10, 1962.

SORGHUM AND MILLETS

House, L. R. Environmental effect on the seed set resulting from cross pollinations on Male Sterile Kafir 60. *Sorghum Newsletter*, Vol. V, 1962.

House, L. R. Information on the interaction of environment and seed setting in hybrids produced with male sterile female parent. *Sorghum Newsletter*, Vol. V, 1962.

House, L. R. and K. N. Jayalakshmi Ayengar. Variation in days to flowering of some varieties grown at several locations in India. *Sorghum Newsletter*, Vol. V, 1962.

Hussaini, S. H. and L. R. House. Some studies of practical interest on seed setting in M.S. Combine Kafir 60 (385-A). *Sorghum Newsletter*, Vol. V, 1962.

Rachie, K. O. The Coordinated Sorghum Improvement Program in India. *Sorghum Newsletter*, Vol. V, 1962.

Rao, N. Gangaprasada. A note on the progress of rabi jowar improvement work at the Regional Research Subcentre, Mohol, Maharashtra State. *Sorghum Newsletter*, Vol. V, 1962.

Young, W. R. Insect control studies. *Sorghum Newsletter*, Vol. V, 1962.

Progress Report of the Cooperative Sorghum Uniform Yield Trials for Kharif, 1960.

Special report on some characteristics of hybrid and parental sorghum variety performance in 1959–1961.

Papers Presented

House, L. R. Results of some chemical weed control investigations in millets. Second All India Millets Conference, Kanpur, September, 1961.

Rachie, K. O. Sorghum improvement in India. FAO Meetings, Rome, July, 1961 (presented in absentia).

Rachie, K. O. Coordination of research on the improvement of millets in India. Second All India Millets Conference, Kanpur, September, 1961.

Rachie, K. O. Methods and techniques in developing hybrid sorghums. Second All India Millets Conference, Kanpur, September, 1961.

Rachie, K. O. Recent trends in sorghum breeding. Golden Jubilee Celebration Meetings and College Day, December, 1961 (presented in absentia).

Rachie, K. O. Future development in cumbu improvement. Golden Jubilee Celebration Meetings and College Day, December, 1961 (presented in absentia).

Young, W. R. and K. O. Rachie. Control of the stem borer, *Chilo zonellus* Swinh., on sorghums with foliage insecticides at New Delhi, India. Annual Meeting of the Entomological Society of America, Miami, Florida, November, 1961.

INTER-AMERICAN MAIZE PROJECT

Ancalmo, Oscar. Enfermedades del maíz en El Salvador. *Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz*, February, 1961.

Rodríguez V., Antonio E. El achaparramiento del maíz en México. *Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz*, February, 1961.

Schieber, Eugenio. Principales enfermedades del maíz en Guatemala. *Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz*, February, 1961.

Wellhausen, E. J. El estado actual y trabajos que se proyectan para el mejoramiento genético del maíz en Centro América y Panamá. *Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz*, February, 1961.

Wellhausen, E. J. Weeds and man in Latin America. *Weeds* (Weed Society of America). In press.

Memoria de la VII Reunión Centroamericana—Proyecto Cooperativo del Mejoramiento del Maíz, Tegucigalpa, Honduras, February, 1961.

Paper Presented

Wellhausen, E. J. Results of inter-American yield tests. Fifth meeting of the Inter-American Society of Agricultural Scientists, Buenos Aires, Argentina, November, 1961.

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